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Motion

IT IS not difficult to conceive of matter as eternal and imperishable — world without beginning as without end— but whence came and how began the motion that with its intricate interactions has produced from that matter the moving, living universe as we know it?

All motion is relative. A passenger sits in a railroad car at rest relatively to his surroundings, but in rapid motion relatively to the passing landscape.

A ball thrown backward from a train with the same velocity that the train is moving will fall dead to the ground. A particle of steam, if thrown backward from the swiftly moving blade of a turbine with a velocity equal to that of the blade, would drop inert and motionless relatively to the casing, all of its energy of motion given up to the runner.

A body once in motion would remain in motion for all eternity with the same velocity and in the same direction unless acted upon by some force that induced motion in some other line.

A bullet fired vertically would keep on forever if no other force acted upon it, but the instant it begins to rise it begins to fall. Its velocity at any instant is the component of the upward velocity with which it leaves the gun and the downward velocity imparted by gravity, to say nothing of other disturbing influences.

When its downward velocity equals its upward velocity, it comes to rest. It is, so to speak, moving in opposite directions at the same speed, and the component of these velocities in this line is zero, or rest.

We are accustomed to thinking of rest as the natural condition of matter because in our environment it is held to the earth by gravity and shares with us the earth's momentum and we are obliged to use force to move it, but in fact rest is a complex condition made possible only by a delicate balance of all the forces and velocities to which the body is subject.

F. R. Low

Engineering Schools Should Teach Economics

RECENTLY, an engineer had occasion to make a study of the water-pumping costs of a Western town. He was most careful in running his tests on water delivered, fuel consumed and on all the other items making up the operating charges. His study of the repairs made over a period of seven years gave an accurate value to the proper maintenance charge to assess against the plant. In fact, this portion of the report revealed a high degree of engineering intelligence and painstaking tabulation.

When, however, he turned economist and set about to erect the proper capital-charge structure, he revealed that, while his purely engineering training had been excellent, his understanding of economics was little above that of a village grocer.

This municipality had built the pumping plant by a bond issue bearing less than five per cent interest charge, yet this engineer-economist placed interest at seven per cent because private lending gave this return. In addition, when computing depreciation, he used seven per cent yearly charge. Now, if a depreciation charge is set up, the invested capital decreases each year by this amount. Consequently, the interest should either be calculated on the basis of a diminishing capital or a diminishing depreciation.

To make the situation still more illogical, when comparing the cost of operation of the present plant and purchased energy, this engineer ignored the fixed charges on the present plant when estimating the cost with purchased power, even though the investment still exists in the shutdown plant.

This man's process of reasoning is identical with that of many others in the profession. The fault is traceable to a lack of training in economics, with which the technical schools are chargeable.

Knowledge Should Be Recorded In Permanent Form

MODERN civilization rests squarely on a foundation of facts, painfully acquired by the men of past ages. Students of prehistoric ages tell us that advances in knowledge made in those days were exceedingly slow, mostly because of the lack of any method of easily recording and transmitting the sum of scientific and social lore then available.

Since the use of printing became general, the recording of knowledge in books has increased at a continually accelerating pace. An ever wider and more rapid spread of the existing fund of facts has resulted, and both material and social welfare have been advanced with parallel speed.

That this acceleration in the civilization of mankind will continue seems axiomatic, for there are no apparent barriers in the way of the increasing spread of knowledge. But there is one danger that deserves consideration. The books in which the vast accumulation has been stored are but frail things. Age alone is sufficient to destroy them. And catastrophes such as fire, earthquake, flood and war readily wipe them out in vast numbers.

Consider what happened when the Eastern Empire broke up. Constantinople was sacked and partly destroyed, several times. Priceless libraries, containing the results of centuries of study by the greatest of students in the then known world, the Greeks, were scattered. Much of this material was forever lost, and no one knows the resulting retardation in the progress of man.

More or less similar occurrences have lost to the world other stores of knowledge. And the same thing may happen again. It is to be hoped that some more permanent form than the present type of book can be found for the storage, in suitable repositories, of the great body of scientific facts and observations upon which the present social and economic structure is based.

Supply of Coke for Boilers Promises to Increase

RECENT developments in the city gas industry presage a possible change in the available fuel supplies of certain localities. Where coal must be hauled a sufficient distance to make it relatively high in price, there has always been a good market for the residue coke, after the desired sizes for furnace, foundry and domestic use have been screened out. Such coke—breeze, dust and fines—has been burned under boilers, where available, with good results, particularly when a suitable stoker was used.

But the supply of this coke has not been sufficient to give it a very wide use so far. In steel mills and other industries having coke plants it has been used in the power houses. And coke oven plants have also used it.

Now, however, the trend of the gas industry toward a much wider use of coke ovens promises that coke will be burned under boilers in larger quantities. For instance, in New Haven a coke company is building a plant that will produce about 300,000 tons of coke annually. Perhaps 60,000 to 75,000 tons of this will be available as boiler fuel. Some of this coke will be needed by the company's own power house. The remainder will be available for power houses in the vicinity, probably at a price somewhat below that of coal in the local market.

This same sort of thing will occur in many other communities during the next few years. It is worth keeping in mind, for those who can purchase and economically use this fine coke will profit thereby.

Ferreting Out the Obsolete

A FEW industries have long recognized the distinction between depreciation and obsolescence, but too many still judge the adequacy of equipment by its mechanical condition. Careful operation and maintenance may permit a machine, after years of service, to perform as efficiently as the day it was installed, yet improvements in design or practice, during this period, may render its retention a distinct liability. This is especially true where competition must be faced from thoroughly up-to-date plants.

That the situation is an important factor in the inability of some firms to compete on a profitable basis, is recognized by the United States Department of Commerce, which has announced its intention to begin a survey of obsolete industrial equipment.

Much helpful information will undoubtedly issue from the survey—information of value to both the users and the makers of such equipment. As a contribution to industry it should measure up to the many other services performed by the Department. The task is great but the effort is well warranted.

The Field for the Large Diesel

ON ANOTHER page the head of a large Diesel engine works discusses the field of application for the large Diesel. As this particular builder's predecessor introduced the Diesel into the United States thirty years ago and has been building engines continuously since then, the opinions he expresses should carry weight. But the field is far greater than is revealed or appreciated.

Undoubtedly, there is a steady change from reciprocating steam engines to Diesel drive in maritime circles. But the development of high steam pressures and pulverized-coal apparatus threaten to make the marine struggle between steam and oil less one-sided. When the author turns to the stationary field, he sees little chance of application save in central stations. Unfortunately, the tendency in central-station practice is toward consolidation of the power supply. It is in the smaller plants only that the Diesel can compete, for in spite of the lower thermal efficiency of the steam plant, the lower cost of coal on a heat-content basis makes the generating cost of the large steam station less than that of a similar powered Diesel plant.

An examination of industry reveals that the real field for Diesel engines up to three thousand horsepower is in the mills and factories. In these establishments the load factor is high so that the ovehead charges of a Diesel plant are not burdensome. In addition, such factories must always be situated so as to take advantage of low labor costs and low power costs. Unfortunately, the two factors seldom are favorable in any single locality. With power developed cheaply in a Diesel power plant, industries need no longer cluster about a spot where purchased energy is cheap and where, owing to the density of demand, labor costs are high. To the impartial observer the large Diesel's rôle is to act as a decentralizer of industry.

Get the Operator's Viewpoint

HOW often is a piece of equipment discredited through an unsympathetic attitude on the part of the operating force. Sometimes this is due to prejudice, but more often to the fact that it has been put in without consulting the operator or he has not been made thoroughly acquainted with its functioning and its limitations.

The equipment may be all right in itself, but its application is seldom universal. A slight change in the hook-up or operating procedure may be all that stands between failure and success. The operator has to live with the equipment and, if enthusiastic and anxious to make it succeed, can usually see these opportunities and make the necessary recommendations.

While the ultimate decision in the selection of apparatus usually rests with designing engineers, or the responsible power executive, whatever his title, the experience of some of the most successful companies shows that it pays to make the operators all the way down the line feel that their opinions are sought and respected. Not only should they be made to feel this, but their opinions should receive full consideration.

In these days of consolidations in both the central-station and the industrial fields, entailing centralized engineering and supervision, it is more difficult to carry out this idea, but it can be done. It will save money for the management and in many cases eliminate unnecessary friction with the manufacturer.

Higher Steam Temperatures

MUCH has been written of the desirability, from an economy viewpoint, of increasing steam temperatures in central stations over present practice. In America this has been specified at 750 degrees F. or less, although several plants have run for considerable periods over eight hundred, and one experimental installation is being laid down for operation at over a thousand degrees. Some maintain that the strength of steels diminishes rapidly as temperatures increase above 750 degrees and that the phenomenon of creep will lead to the ultimate failure of all steel parts subjected to stress at these high temperatures. No sufficiently long creep tests have been made as yet to determine what this ultimate is. Tests extending for a period of a year and a half indicate progressive creep of relatively small magnitude.

On the other hand, many have pointed out the extended and satisfactory use of much higher temperatures in Europe and also in the oil-refining industries of this country. While much has been said in a general way about the latter practice, no one seems to have collected actual data from the oil companies and to have analyzed their life records of piping, valves, etc., in order to enable engineers to draw conclusions as to applicability of these higher temperatures in central stations. This would seem to be a worth-while investigation for some of the power-stations committees of our National Societies.

Is Study of Competition a Waste of Time?

IN THE current issue of the *Magazine of Business*, Henry Ford, in discussing the things that make a business successful, said that time spent in studying a competitor's business was time lost. In his opinion it is much more fruitful to devote this effort and study to the conduct of one's own business. When a business is organized and operated as well as it can be and its product is suited to the needs of the consumers for whom it is made, competition can safely be neglected.

This is a radical departure from current business practice in many concerns, so much so that it amounts to an inversion of customary thinking. Yet, like all that Mr. Ford says on manufacturing and business, it carries the weight of authority and is worth pondering.

And the same thought, paraphrased to suit the different conditions, can be applied with profit to other activities. For instance, competition between the central station and the isolated plant has led to much wasted time on the part of power engineers. If they would put this time in on study of their own plants or services to see how these could be improved, in most cases it would be found that there need be no fear of competition.

Where this is not the case, it is generally because the competitor can serve more economically. There are today some industrial power plants that should give way to central station service, and some plants that purchase current which should be generated in their own power houses, all in the interest of better economy.

In the majority of cases, however, power is now secured from the correct source. If power engineers will stick strictly to their own interests and not worry over what the other fellow is doing, it is certain that competitive methods of furnishing power will have little chance of winning their business from them to the detriment of economy.

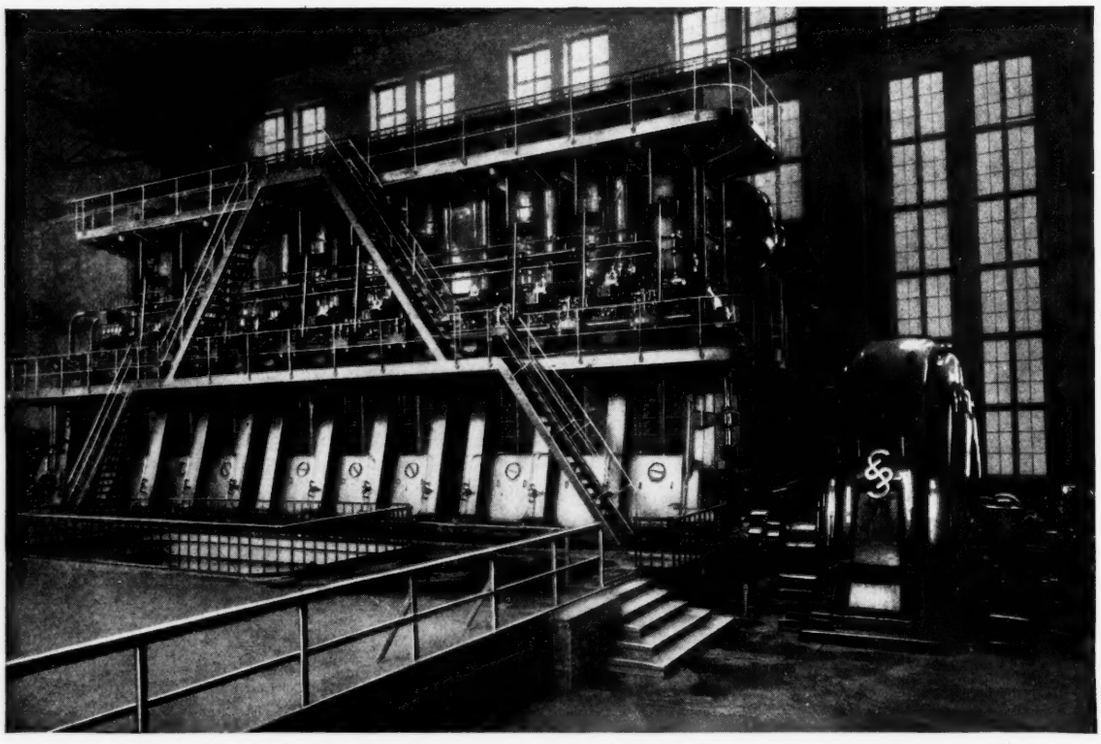

Fig. 1—15,000-hp. Diesel in Hamburg, Germany, light plant

The Large Diesel's Place *In Industry*

By Edward B. Pollister
General Manager, Busch-Sulzer Bros.-Diesel Engine Company, St. Louis, Mo.

AS A general statement, the United States is a country of cheap coal, and as the greatest industrial developments originally centered around the coal mines of the East, the great power-plant engineering problems have been worked out without any consideration of the Diesel whatsoever. Obviously, steam plants of half the thermal efficiency of the Diesel, using local cheap coal, can produce power at less fuel costs than Diesels requiring liquid fuel if the cost of the liquid fuel at the oil field plus the cost of transportation (which is often several times the cost of oil at the point of production) is sufficiently in excess of twice the cost of local coal on a B.t.u. basis to offset the stand-by coal consumption of the steam plant. Of course we shall always have with us Diesel enthusiasts who believe that Diesels can beat steam under all conditions. But consider a large up-to-date steam-turbine installation in East St. Louis, burning 12,500-B.t.u. Illinois coal, available at $2 a ton. Such a plant will produce a kilowatt-hour at a fuel cost of between one and two mills; while a Diesel using 5-cent oil brought from Oklahoma, cannot produce a kilowatt-hour for less than twice this fuel cost. This is an example of steam territory, and only in exceptional cases is a Diesel more economical.

But this is a country of vast area, and there are large sections, especially through the Middle West and along the seaboard, remote from coal mines, and within easy reach of oil fields or a cheap supply of fuel oil transported at low cost in ocean-going tank ships. These are decidedly examples of Diesel territory.

Also, industry is moving westward with the center of population, and the demand for power throughout the great West is growing with the increase of population. This is favoring the more general adoption of the large Diesel.

The consumption of fuel oil in generating electric power by public-utility power plants in 1927, totaling 6,782,199 bbl., shows that there are well defined terri-

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tories where oil is the logical fuel—and the Diesel is the logical prime mover.

The distribution is shown in Table I.

TABLE I—CONSUMPTION OF FUEL OIL

Division	Barrels	Per Cent of U. S. Total
New England	858,289	12.65
Middle Atlantic	342,462	5.05
East North Central	68,456	1.01
West North Central	815,534	12.02
South Atlantic	2,048,991	30.21
East South Central	57,977	0.86
West South Central	929,581	13.71
Mountain	225,889	3.33
Pacific	1,435,020	21.16

At least one-half this 6,782,199 bbl. of fuel oil could be saved if it were burned in Diesel engines instead of under boilers. This would be a saving of easily over $5,000,000 in public-utility fuel costs.

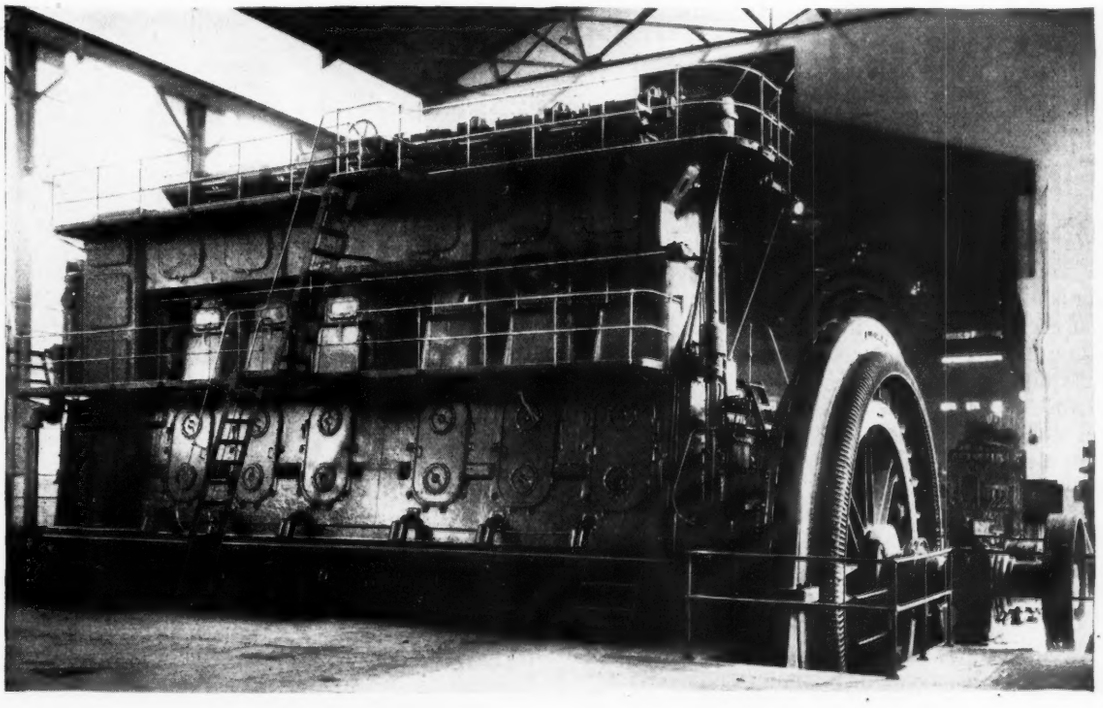
The comparative thermal efficiencies of Diesel-engine generating units and large steam-turbine plants are too well known to justify repeated technical discussion. There are large plants on the Atlantic seaboard, for instance, the Narragansett Station, where fuel oil transported in tankers is burned under boilers. The average fuel consumption per kilowatt-hour in such large modern steam plants is about 1.2 lb. of fuel oil as compared with about 0.6 lb. burned in large Diesel engines. Varying load conditions and types of equipment may, for particular installations, change slightly these figure, but they are approximately correct.

The next question to consider is whether this saving of $5,000,000 would be dissipated by fixed charges on higher Diesel plant costs or higher Diesel operating costs. While steam-plant costs are quite generally known, this information is not obtainable on large Diesel-engine plants, owing to lack of such installations. With so many concerns offering large Diesels in advance of actual building, prices quoted are very unstable, the market not having become established. Again, the ultimate price of large Diesel engines will be determined only after sufficient orders have been placed to produce these engines on other than single-engine orders with comparatively high cost of manufacturing.

A proper question may be, "What is a *large* Diesel engine?" Diesels built by Sulzer Brothers, of Winterthur, Switzerland, of 4,000 hp. capacity have been operating in European land stations for over fifteen years. In the same year (1924) that the Panama Canal invited bids on 3,750-hp. Diesel engines, the Hamburg Electric Company, of Hamburg, Germany, placed an order for a 15,000-hp. two-cycle double-acting M.A.N. Diesel generating unit for installation in its electric generating station to carry peak loads. This unit is shown in Fig. 1. While this is the largest Diesel now in operation, Sulzer Brothers have developed a single-cylinder experimental double-acting two-stroke-cycle engine rated for stationary work at 2,400 b.hp. at 110 r.p.m. with a cylinder bore of 900 mm. and a piston stroke of 1,400 mm. A 10-cylinder engine of this size would develop 25,000 b.hp. This number of cylinders is frequently employed in marine work, and Sulzer Brothers have supplied eight 10-cylinder units averaging above 5,000 hp. each for propelling ships. As 900 mm. diameter of cylinder is not the limiting size, a former Sulzer single-cylinder experimental engine having a bore of 1,000 mm., somewhat larger units are not without the range of conservatism. A large Diesel may therefore be considered as of from 2,500 to 25,000 b.hp.

Contrary to general opinion, however, based on actual selling prices of the few large Diesels that have been sold in this country, the cost of large Diesel-engine generating stations is approximately that of modern steam plants. In fact, in many cases the cost of the Diesel plant is less, depending upon the varying costs of providing condensing water for the steam plant. Formerly, Diesel engines were comparatively high in price, but today they rank with the very few commodities that are being sold for less than pre-war prices. Large stationary Diesels cost less than $60 per horsepower and the total cost of a large Diesel generating station is normally around

Fig. 2—A 3,750-hp. Busch-Sulzer Diesel in Tucson, Arizona plant



$135 per kw., made up about as follows for average conditions:

TABLE II—ESTIMATE OF COST OF A FOUR-UNIT, 15,000-B.HP. 10,000-KW. DIESEL INSTALLATION

Real estate	$10,000
Building, including 20-ton crane	75,000
Foundations	40,000
Four 3,750 b.hp. Diesel engines, f.o.b. point of manufacture	900,000
Freight on engines at $1 per cwt.	40,000
Generators and exciters, direct-driven	100,000
Freight on generators and exciters	5,000
Unloading and placing on foundations	15,000
Erection	15,000
Station piping	15,000
Cooling-water system (if required)	25,000
Fuel storage	10,000
Switchboard and wiring	20,000
Miscellaneous items, contingencies, and engineering	80,000
Total	$1,350,000
Diesel station cost per kilowatt of installed capacity	$135

The installation is extremely simple, approximately only one-half of the floor space being required that is necessary for turbine installations. The building is somewhat lower, and expensive smokestack and coal- and ash-hauling apparatus are absent.

As the size of the Diesel increases, the maintenance cost diminishes. The replacing of a working part of a 36-in. diameter cylinder rated at 2,000 hp. does not cost ten times as much as a similar part on an 18-in. cylinder rated at 200 hp. This is apparent and will become established in this country after more of these large Diesels have been installed.

Similarly, the same operator who takes care of a 500-hp. Diesel engine can as well take care of a single engine several times as large. There is no more to do while the engine is in operation. Adjustments and upkeep work would be somewhat greater of course, but not in proportion to the increased size of the larger engine.

And so this fuel saving would be a net saving and would add to the net income of public utilities.

Here, then, is the first economic place for the large Diesel engine, in sections of the country where the price of Diesel fuel on a B.t.u. basis compares favorably with the price of steam fuel.

The task remains, however, of convincing "dyed in the wool" steam engineers, who will, of course, still insist on having steam at any cost. Before reaching a decision to purchase the 3,750-hp. Diesel for installation at Tucson, clearly a Diesel territory, one of these "steam" engineers organized an exploring party to see if a coal stratum could not be discovered in that locality. The geographical division of the country into cheap-coal and cheap-oil territory is a logical step in the first consideration of the large Diesel. But this is only the first step, and possibly a more important use of the Diesel is as an auxiliary to even the largest power plants, both steam and hydro-electric, because of characteristics it possesses which are too frequently overlooked. In fact, because of its limitations in size, the Diesel will never be a competitor of the largest steam turbines, but it can be very advantageously used as auxiliary capacity, as follows:

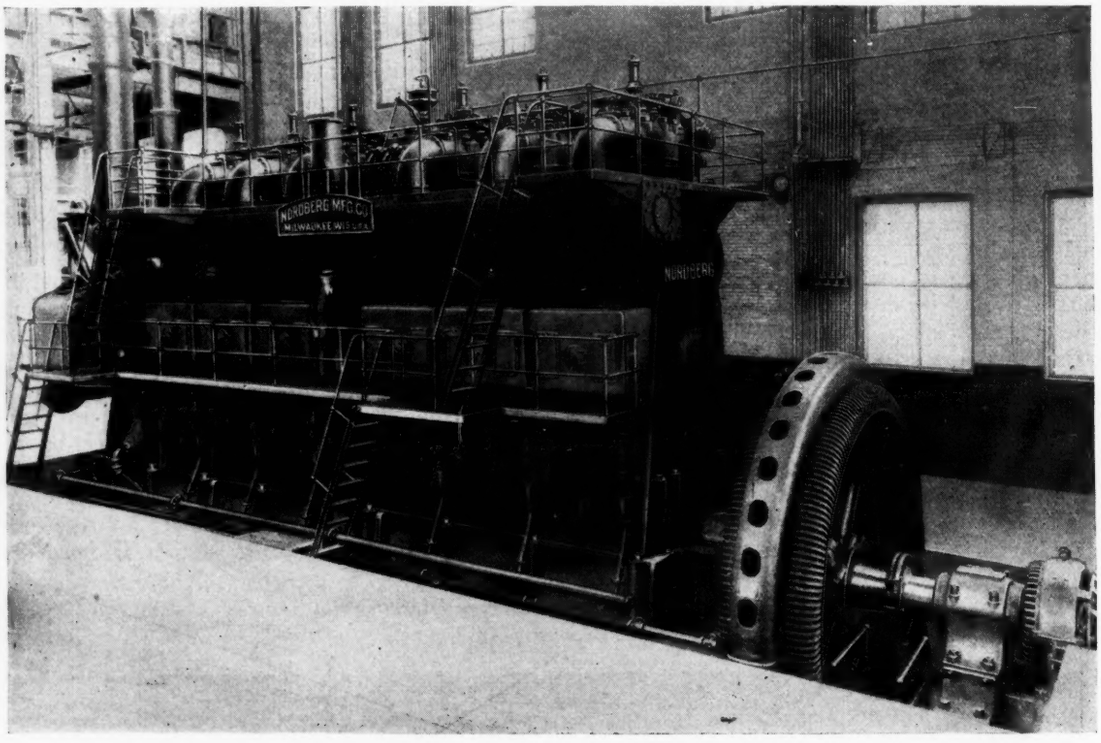


Fig. 3—One of the 3,750-hp. units now installed on Panama Canal

1. By carrying normal peaks, permitting steam equipment to be operated at most favorable constant loads with highest efficiency.
2. For emergency peaks.
3. As stand-by and reserve to high-lines.
4. Hydro-electric auxiliary.

Self-contained, with a minimum of piping and auxiliary equipment, and using easily handled and stored fuel, capable of delivering full output within a few minutes' time, simple to start up, the large Diesel generating unit, costing no more per kilowatt of installation than the over-all steam plant, forms a very desirable 10 or 20 per cent of the capacity of quite large steam-turbine generating stations. The daily peak load is the bugbear of the central-station efficiency operator. It is

usually of short duration, two or three hours only, but must be provided for either by firing up additional boilers and warming up additional turbine capacity, or operating the remainder of the day at less than the maximum efficiency loading of both. Once adopted as part-station capacity for carrying peak loads, the large Diesel will quickly become a favorite apparatus with the chief engineer and the efficiency engineer of the large power plant, as well as with the owner.

Another distinct field for the Diesel is as a hydro-electric auxiliary plant. During times of low water flow the Diesel may be operated with minimum attendance; depreciation is practically absent when shut down, in contrast to the heavy depreciation of idle steam equipment; the fuel is safely stored for long periods without danger of spontaneous combustion or depreciation from weathering; and the plant is compact and lends itself readily to installation in the hydro-electric turbine power house, to which the fuel is delivered by gravity pipe line. A single attendant can start even quite a large engine to carry occasional peak loads; and for more sustained seasonal operating, additional personnel can be supplied as required. The life of a Diesel operating as stand-by auxiliary is almost indefinite, the working parts being bathed in oil and not subject to rusting or deterioration. Where water-storage capacity is sufficient and peak loads exceed the capacity of a hydro-electric plant, the Diesel auxiliary may be operated as a hydraulic accumulator, pumping the water back over the dam to storage during light-load periods of the day, as well as adding its capacity to the hydraulic turbines during peak loads. This plan is at present being studied by a public utility.

Extensive study of the advantages of large Diesel hydro-electric auxiliary plants has been made during the last ten years, and each time the lack of actual installations of large Diesels has introduced an experimental hazard which for so large an investment has prevented consummation of such plans. This hazard has now been eliminated by the very extensive building of large marine engines, advantage of which will no doubt be taken by engineers in charge of super-power development, embracing both steam and hydro-electric power plants, with its network of distribution lines.

So far, in dealing with this subject, the use of the large Diesel engine by public utilities has been alone considered, and this is by far the largest field. To what extent the large Diesel is adopted by industry depends to a great degree on the attitude toward it manifested by the public utilities.

If the large Diesel-engine installation has merit as a low-cost power producer, it cannot be stifled, for the simple reason that industrial plants will be able to produce their own power with large Diesels at lower costs than central station companies can afford to supply it. Already the greater number of American Diesels of medium size, 1,000 to 2,500 b.hp., are installed in private industrial plants. One of these plants at the Moctezuma Copper Co., Nacozari, Son., Mexico, consists of two 2,200-hp. and four 1,250-hp. engines supplied by the Nordberg Manufacturing Company. At the end of 1924 this plant was reported, after some of the units had seen five years of service, to have had a record of gradual reduction in maintenance cost and entirely successful operation. Investigation over a period of years of the operating results of similar engines within this range of sizes recently led the Commerce Mining & Royalty Company of Cardin, Oklahoma, to install a 6,750-hp. Nordberg Diesel plant consisting of three 2,200-b.hp. engines.

Applying Chain Drives

CHAIN drives have come into use for a wide variety of purposes. Associated with these drives are a number of terms that one should be familiar with before one can expect to handle such problems intelligently. In the following is given an explanation of the commonly used chain-drive designations, which are published by the courtesy of the Link-Belt Company. These terms form a valuable adjunct to the leading article in last week's issue, which dealt with the selection of chain drives on cast-tooth sprockets. The slower speeds given are for malleable-iron chains, and the higher speeds are obtained with bushed steel-roller chains with hardened bearing surfaces and rollers.

TERMS USED IN CONNECTION WITH CHAIN DRIVES

THE CHAIN DRIVE—A chain drive consists of three elements: The driver sprocket on the shaft furnishing the power, the driven sprocket on the shaft receiving power, and an endless chain which transmits the power from the driver sprocket to the driven sprocket.

PITCH—The distance from center to center of two adjacent chain joints is the chain pitch, and sprocket pitch (usually stated in inches).

PITCH CIRCLE AND PITCH DIAMETER—Imagine a short endless chain all links of which are in mesh with the teeth of a sprocket. A circle drawn through the centers of all the chain joints is the sprocket's pitch circle, the diameter of which is the pitch diameter of the sprocket, shown as the "pitch diameter" in sprocket lists.

SPROCKET-WHEEL SPEED—The speed of a sprocket is stated in r.p.m., and is the same for every wheel keyed on the same shaft.

PITCH-LINE SPEED AND CHAIN SPEED—The number of teeth in the sprocket, times the pitch of chain in inches, times its r.p.m. equals its pitch-line speed in terms of inches per minute. Dividing by twelve gives it in feet per minute. The sprocket's pitch-line speed is equal to the velocity or speed of the chain.

POWER AND THE DRIVE—Power is the time rate of doing work and amounts to pull in chain times velocity. A heavy load may be moved slowly or a light resistance overcome rapidly, by the same amount of power. Usually a drive bringing power to a shaft performs the further duty of imparting a rate of rotation suitable to the work.

THE MECHANICAL UNIT OF POWER—One horsepower is the amount of power required to raise a weight of 33,000 lb. one foot in one min.; or one pound 33,000 ft. in one min.; or 330 lb. 100 ft. in one min.; etc. One horsepower amounts to 33,000 ft.-lb. per min. (Pounds times ft. per min. equals foot-pounds per minute).

TO TRANSMIT A UNIT OF POWER—To transmit one horsepower, the velocity in ft. per min. of the chain, times the pull in pounds, equals 33,000 ft.-lb. per minute.

$$\text{Hp.} = \frac{\text{Speed in ft. per min.} \times \text{pull in pounds}}{33{,}000}$$

WHEN TO USE CHAIN DRIVES—Chains are particularly applicable where a positive drive is required and where speeds are not excessive.

SPEED OF CHAINS—In chain-drive calculations the pounds pull may be as high as the strength of the chain permits. Hence, chain speed may be correspondingly low (best range 200 to 600 ft. per min.) permitting use of small sprockets.

Recent French Developments in Surface Condenser Design

By R. H. Andrews
Consulting Engineer
Paris, France

In THE May 29 issue the writer discussed the design of condensers Nos. 1 to 5 in the Gennevilliers station. Condenser 6 in this plant is manifestly an experiment, the object being to prove that the general performance of the condenser could be improved by the removal of nearly 2,000 tubes. The experiment was undoubtedly successful, as two other condensers have since been altered in the same manner, and the remainder are to follow.

The condensing-water problem at Gennevilliers is a difficult one, particularly in the Summer, when the Seine water bears a large amount of mud of a consistency that seems to foul the tubes so rapidly that thorough tube-by-tube cleaning is prohibitive. The practice of tube-by-tube cleaning has been completely abandoned in this station in favor of a modified baking process that might be qualified as "wet baking." Steam is turned into the condenser without draining the water from the tubes, the generating unit and the circulating pumps being simply shut down. This loosens the slime sufficiently to allow its removal when the pumps start up again and has the double advantage of being rapid and cheap and of leaving the tube packing unimpaired.

In this second article on French condenser design, performance tests on the Gennevilliers condensers indicate that high rates of heat transfer can be obtained with condensers having a large proportion of tubes exposed to the direct impact of the steam, and with the tube bank arranged for tangential flow of condensate.

The five condensers installed gave so much trouble from fouling that, at the time of the installation of unit No. 6 it was decided to increase the condensing surface, although the condenser had been built identical with those of the other units.

However, before resorting to the expedient of adding more tubes to the bank, it was proposed to first try reducing the condensing surface. Therefore, when the condenser was being tubed, nearly 2,000 of the total number of 7,500 tubes were omitted, so as to widen the steam lanes by an amount varying from 100 to 250 per cent. Fig. 1 shows the reduced cross-section of the tube bank, the broken line indicating the outline of the bank as originally planned, identical to that of the older units. This amounts to a withdrawal of the front line of the condensing surface, so as to allow the steam more room to flow freely almost to the bottom of the bank.

The experiment was a success. Condenser 6 is reported by the superintendent of the station to give a better vacuum than any of the five other condensers, with approximately 10 per cent less circulating water and about the same power consumption for pumping. The most important advantage gained is a marked reduction in the tendency to fouling. This is apparent, with the exception of the first month recorded, from Table I, which gives the maintenance record for a six-months period for the three condensers.

The importance of establishing beyond discussion that, under certain conditions, the performance of a condenser may be improved by reducing its surface, and the bearing of such a fact, once it has been proved, on the technique of condensation, need not be emphasized. The writer was therefore prompted to make a study of the test results obtained with condensers 3 and 6.

The available data for this comparative study consisted of the acceptance test performed on condenser No. 3, then in good operating condition, with circulating water at 39.9 deg. (results given in Table IV and in curve C, Fig. 3), a test performed on condenser No. 6 shortly after its erection and after a thorough cleaning (results given in Table II and in curve E, Fig. 3) and three tests on condenser No. 6 when in good operating condition, that is, after wet baking (results given in Table III). The first of the last three tests was made after 1,400 hours of service without cleaning other than wet baking, and the other two tests after several thousand hours of service under the same conditions. The tests on condenser No. 6, reported in Table II, may be taken as the maximum performance obtainable from this condenser.

For convenience in comparing the performance of No. 6 with that of No. 3, or of any other condenser, the curves in Fig. 4 were plotted from the last three tests on condenser 6. From these an approximate condensa-

tion curve for any water temperature between 46 and 72 deg. can be rapidly drawn.

Referring to Fig. 3, curve *A* is a condensation curve obtained with condenser 1, the cross-section of which was shown in Fig. 3 of the previous article. The circulating water was at 41.7 deg. F. Curve *B* is a test curve for condenser 6 with 46.4 deg. circulating water. Curve *C* is a test of No. 3 with 39.9 deg. water. Curve *E* represents the maximum performance of No. 6, taken with

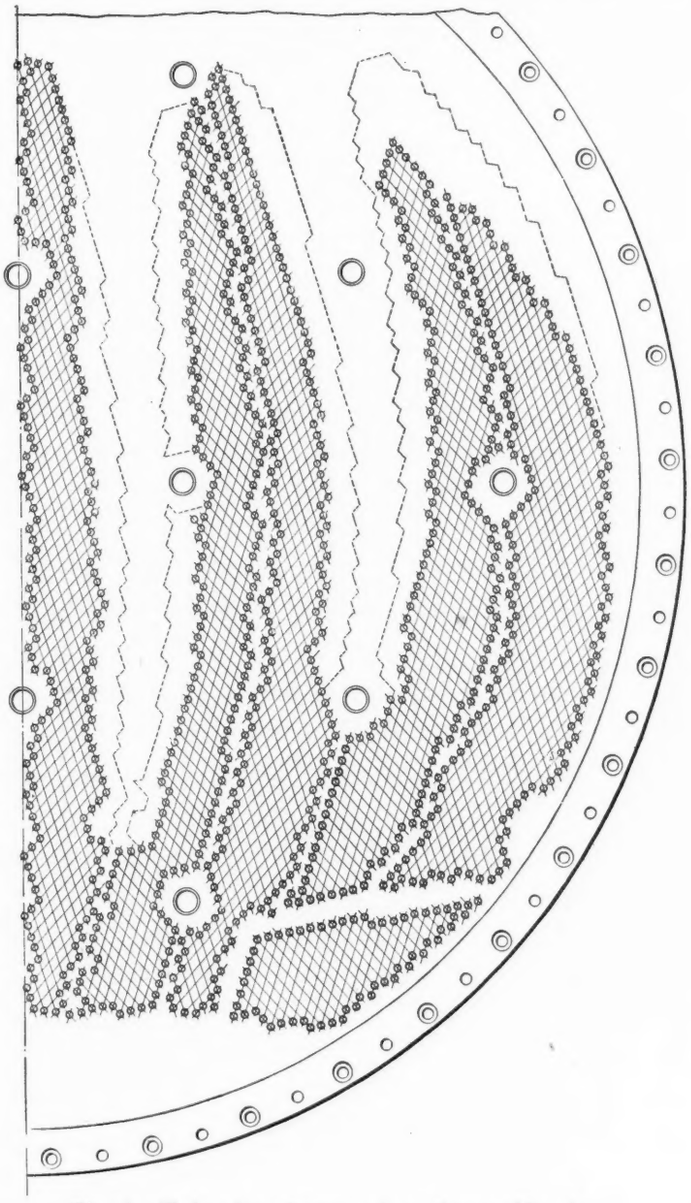


Fig. 1—Tube-sheet layout of condenser No. 6, Gennevilliers central station

45.5 deg. water. Curve *D* is the probable condensation for No. 6 at the same cooling-water temperature as curve *C* for No. 3, and was obtained from Fig. 4, by extrapolating to a temperature of 39.9 deg.

The performance of condenser No. 1, curve *A*, is hopelessly inferior to that of the other units, in spite of the advantage of 4.7 deg. colder circulating water than No. 6 in curve *B*. Quantitatively, the performance of No. 6 condenser represents a 51 per cent increase in capacity, at a 29-in. Hg. vacuum, with 26 per cent less surface, or a 103 per cent higher condensing capacity per square foot of surface, disregarding the important handicap due to warmer circulating water. All the units in the Gennevilliers station are equipped with substantially the same air-removal equipment and the absolute pressure at the air suction was probably lower for No. 1 than for No. 6, in these tests.

The difference between the performances of condensers Nos. 3 and 6 is less marked, yet the superiority of No. 6 is unmistakable. Curve *C*, No. 3 condenser, is only slightly above curve *B*, No. 6 condenser, in spite of

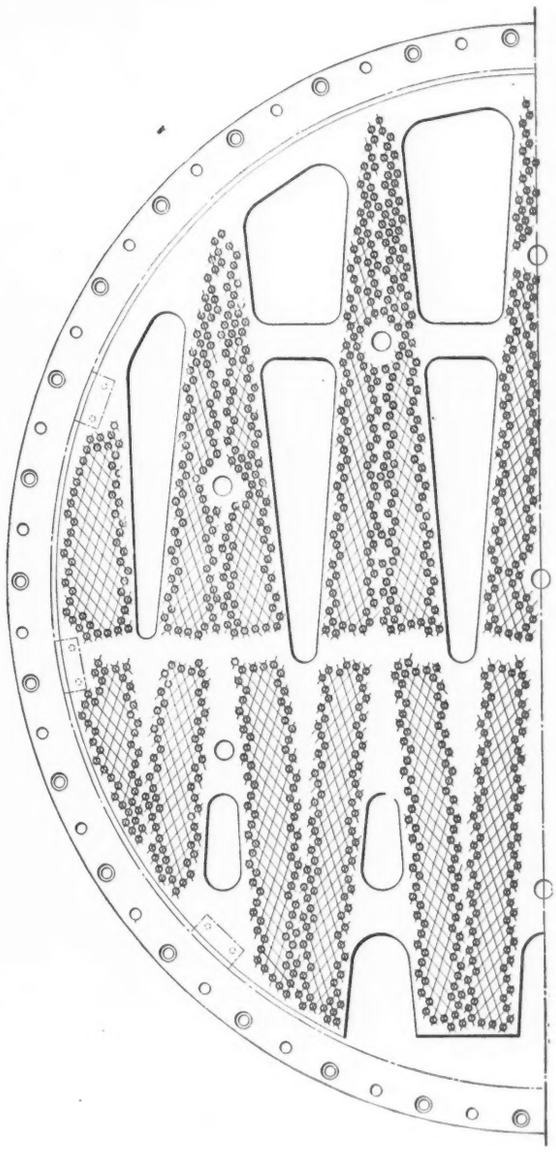


Fig. 2—Cross-section of an 11,600-sq.ft. condenser recently installed in a Paris plant

a 6.5 deg. lower circulating-water temperature. An important point is that curve *C* drops more rapidly than *B*, which indicates that condenser No. 3, with 37,650 sq.ft. of surface, is less able to handle the heavier loads than No. 6, with only 27,750 sq.ft. This is confirmed by consideration of curve *D*. Inasmuch as this curve was constructed by extrapolation from the curves in Fig. 4, it should not be taken as an accurate numerical expression of the performance of condenser No. 6 with 39.9 deg. water, but it is fair to take it as a qualitative indication of the trend of the true condensation curve at this temperature. Though curves *C* and *D* coincide at low con-

densation rates, which is logical, curve *C* falls off more and more rapidly at heavier loads. This indicates in the tube bank of No. 3 a greater tendency to become choked up with steam at higher condensation rates, in spite of —or rather because of—its 35 per cent greater condensing surface.

Discussion of Causes of Improved Performance with Reduced Surface

In studying the possible causes of the improved performance with reduced condensing surface, the following factors are considered: The quantity of circulating

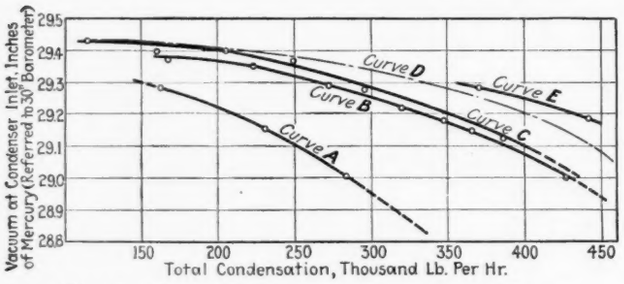


Fig. 3—Capacity curves for condensers Nos. 3 and 6, Gennevilliers station

water, the water velocity in the tubes, the efficiency of utilization of the condensing surface.

In view of the great difficulty and relatively minor importance of accurate measurements of circulating-water quantities, it is customary to accept quantities computed from the temperature rise and the total amount

TABLE I—GENNEVILLIERS CENTRAL STATION MAINTENANCE RECORD, CONDENSERS NOS. 2, 3 AND 6

			Wet Bakings		Tube-Sheet Cleaning		Tube-Packing Renewal	
Month, 1925	Unit No.	Total Hours of Service	Number	Hours of Service between Bakings	Number	Hours of Service between Clearings	Number	Hours of Service between Renewals
July	6	621.15	11	56.5	11	56.5	13	47.8
	3	595.15	10	59.5	5	119.0	11	54.1
	2	378.30	15	25.2	12	31.5	17	22.3
Aug.	6	479.40	8	60	5	96	9	53.3
	3	508.15	14	36.3	7	72.6	14	36.3
	2	390.30	15	26	8	48.8	15	26
Sept	6	597	10	59.7	6	99.5	10	59.7
	3	481.45	9	53.5	7	68.8	9	53.5
	2	403	10	40.3	9	44.8	12	33.6
Oct.	6	627.15	2	313.5	8	78.3	5	125.5
	3	597	1	597	11	54.2	4	149.2
	2	421.45	2	210.7	20	21.0	2	210.7
Nov.	6	611.30	0	.....	13	47	5	122.3
	3	538.30	0	.....	19	28.3	14	38.4
	2	411.30	0	.....	21	19.6	9	45.7
Dec.	6	573.45	3	191.3	7	81.9	4	143.4
	3	536.15	0	.....	15	35.7	13	41.2
	2	446.15	3	148.8	20	22.3	14	31.9

of heat given up by the condensing steam. This method is known to be inaccurate, partly because of the appreciable error in the temperature measurements, but mainly because the stream of water leaving the condenser shell is not homogeneous and is composed of veins of water at different temperatures. It is, therefore, practically impossible to obtain a dependable average value for the circulating-water temperature.

In the tests under consideration the temperature-rise method tends to indicate that unit No. 3 was using about 5 to 7 per cent less water than No. 6, using the temperature figures recorded in Tables III and IV for the heavier loads. If this were true, it would partly explain the better performance of No. 6, but it has been formally contradicted by Mr. Rauber, superintendent of Gennevilliers station, who states that condensers Nos. 3 and 6 are equipped with identical pumping units, that the circulating-water piping is identical for both units, so that the external head is the same; that their power consumption for pumping is practically the same, varying slightly around 280 hp. per pump, or 560 hp. per condenser. He further states that the aggregate tube cross-section in No. 6 being 26 per cent less than in No. 3, the quantity of circulating water is reduced by about 10 per cent in the former, while the water velocity in the tubes is increased by about 21 per cent.

A decrease of 10 per cent in the quantity of cooling water would raise its temperature range by the same amount for a given load. Other factors remaining equal, this would raise the steam temperature in the condenser and reduce the vacuum slightly. The effect would be approximately equal to that which would have resulted from a 5 per cent decrease in the coefficient of heat transfer, the water quantity remaining the same.

The coefficient of heat transfer being approximately proportional to the square root of the velocity of the water in the tubes, an increase of 21 per cent in the latter will produce an increase of 10 per cent in the heat transfer.

TABLE II—CONDENSATION TESTS ON UNIT NO. 6, EQUIPPED WITH REDUCED SURFACE GINABAT TUBE LAYOUT

Maximum performance, with condenser thoroughly clean. See curve *E*, Fig. 3.
Total condensing surface, 27,750 sq.ft.
Condensing surface per kilowatt, 0.69 sq.ft.
Condensing surface per cu.ft. of shell volume, 10.14 sq.ft.
Diameter of shell, inside, 12 ft. 6 in.
Length between tube sheets, 22 ft. 3.5 in.
Number of tubes, 5,580.
Diameter of tubes—inside, 0.787 in.; outside, 0.866 in.
Total circulating-pump capacity, 70,000 g.p.m. (in 2 units).
Circulation, single-pass.
Circulating-water velocity, 7.5 ft. per sec.
Condenser identical to Nos. 2, 3, 4 and 5 in the same station, except that 26 per cent of the tubes have been omitted

Date	Dec. 10, 1924	
Test number	I	II
Weight of steam condensed per hour, 1,000 lb.	369.7	442.2
Steam condensed per square foot per hour, lb.	13.32	15.93
Absolute pressure at condenser inlet, in. Hg.	0.711	0.812
Vacuum at condenser inlet (referred to 30 in. bar.), in. Hg.	29.29	29.19
Saturation temperature at inlet pressure, deg. F.	68.87	72.81
Cooling-water conditions:		
Temperature, in, deg. F.	45.5	45.5
Temperature, out, deg. F.	55.9	57.63
Temperature range, deg. F.	10.4	12.13
Temperature head at inlet, deg. F.	23.37	27.31
Temperature head at discharge, deg. F.	12.97	15.18
Logarithmic mean temperature head, deg. F.	17.67	20.66
Coefficient of heat transfer (using a heat loss per lb. of steam condensed of 990 B.t.u.	746	763
Volume of cooling water, 1,000 g.p.m.	70.4	72.2
Ratio cooling water to condensate	95.2	81.6
Absolute vapor tension of water at cooling-water inlet temperature, in. Hg.	0.306	0.306
Condenser vacuum in per cent of theoretical[1]	98.64	98.30

[1]The theoretical vacuum assumed is the vapor tension of water at inlet cooling-water temperature.

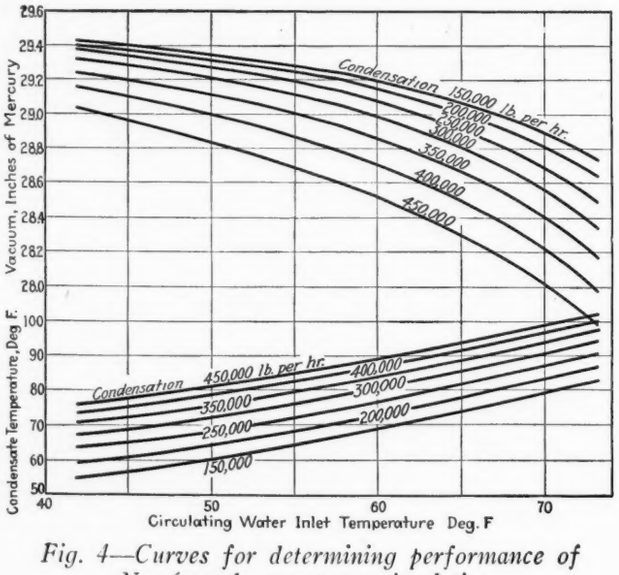


Fig. 4—Curves for determining performance of No. 6 condenser at any circulating-water temperature

The net effect of the changes in quantity and velocity of the circulating water will therefore be closely equivalent to an improvement of 5 per cent in the coefficient of heat transfer. The actual improvement in coefficient of heat transfer between the two condensers being of the order of 60 per cent in favor of No. 6, it is evident that the changes in circulating-water conditions are of minor effect and that the principal cause of the improved performance of No. 6 is the more efficient utilization of the condensing surface.

Utilization of Condensing Surface

In order to make possible a quantitative measurement of the utilization of condensing surface, it might be defined as the ratio of the average coefficient of heat

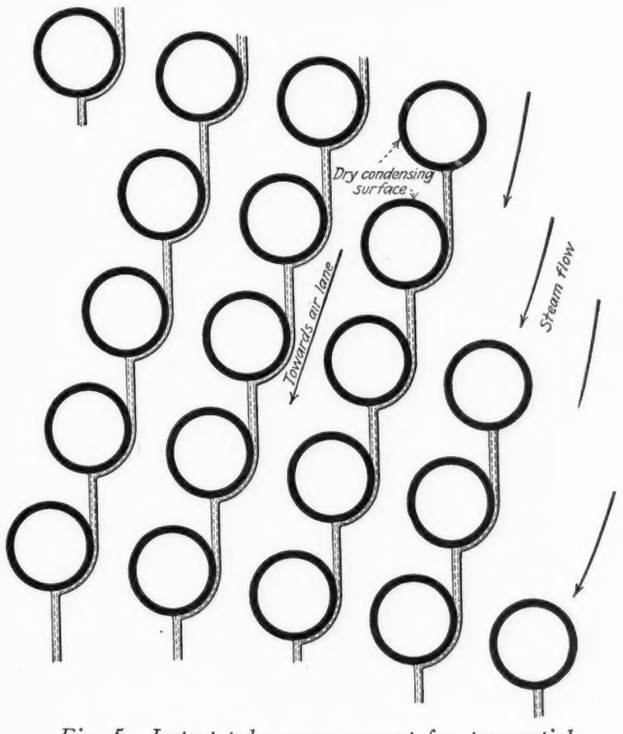


Fig. 5—Latest tube arrangement for tangential flow of condensate

transfer for the condenser bank as a whole, to the maximum coefficient of heat transfer attained in the bank; that is, to the coefficient attained in the top tubes. Extreme accuracy being of minor interest in this case, it might be arbitrarily assumed that the coefficient attainable in the top tubes is 1,500 B.t.u. per sq.ft. per deg. F.

On this basis, referring to Tables III and IV, the efficiency of surface utilization of condenser No. 3, when condensing 386,000 lb. per hour, with 39.9 deg. cooling water is $\frac{353}{1,500} = 23.5$ per cent, whereas that of condenser No. 6, when condensing 425,500 lb. of steam per hour, with 46.4 deg. cooling water, is $\frac{579}{1,500} = 39.6$ per cent.[1]

As an experiment, condenser No. 6 is undoubtedly a success—so much so that two other condensers of this station have since been modified along substantially the same lines and the remainder are to be altered later. Yet the three defects outlined herein in the discussion of the original Ginabat layout remain:

The condensate from each group of tubes drains back into the steam lanes, flooding the tubes in the lower part of the latter, and is, if anything, increased by the widening of the steam lanes.

The condensate comes in contact with a large number of tubes before it escapes to the hotwell.

This defect is materially reduced in condenser No. 6.

The steam flowing through the tube bank must pass directly through the stream of condensate.

TABLE III—CONDENSATION TESTS ON UNIT NO. 6, AFTER WET BAKING TREATMENT

Date of test	Feb. 13, 1925		May 12, 1925		June 16, 1925	
Test number	I	II	I	II	I	II
Weight of steam condensed, 1,000 lb	320.0	425.5	315.4	391.8	330.5	391.8
Steam condensed per sq.ft. per hr., lb	11.52	15.3	11.36	14.1	11.9	14.1
Absolute pressure at inlet, in. Hg	0.784	0.996	1.016	1.278	1.71	1.935
Vacuum (referred to 30 in. bar.), in Hg	29.22	29.00	28.98	28.72	28.29	28.07
Sat. temperature at inlet pressure	71.77	79.0	79.65	86.73	96.07	100.17
Cooling-water conditions:						
Temperature in, deg. F.	46.4	46.4	58.64	58.82	72.5	72.5
Temperature out, deg. F.	55.58	58.39	67.06	69.55	81.64	83.44
Temperature range, deg. F.	9.18	11.99	8.42	10.73	9.14	10.94
Temperature head, inlet deg. F.	25.37	32.6	21.01	27.91	23.57	27.67
Temperature head, discharge, deg. F.	16.19	20.61	12.59	17.18	14.43	16.73
Log. mean temperature head, deg. F.	20.4	26.17	16.42	22.13	18.62	21.76
*Coef. of heat transfer, B.t.u., per sq.ft. per deg. per hour	560	579	685	632	634	643
Volume of cooling water, 1,000 g.p.m.	69.0	70.1	74.3	72.4	71.66	70.8
Ratio cooling water to condensate	108	82.3	118	92.3	108.5	90.3
Temp. of condensate, deg. F.	71.69	79.88	79.45	86.91	97.65	98.89
Temp. drop from steam to condensate, deg. F.	+0.08	—0.88	+0.2	—0.18	—1.58	+1.28
Absolute vapor tension of water at cooling-water inlet temp., in. Hg.	0.317	0.317	0.497	0.500	0.804	0.804
Condenser vacuum in per cent of theoretical	98.32	97.71	98.24	97.36	96.90	96.12

*Based on an assumed heat loss of 990 B.t.u. per pound of steam condensed.

The steam flowing through the tube bank must pass directly through the stream of condensate.

Parallel-Steam, Water and Air Flow in Latest Designs

In the latest Délas condensers these defects have been corrected as indicated in Fig. 5. Instead of draining their condensate back into the steam lanes, the different groups of tubes are oriented in the opposite direction and drain toward the air lanes. The result of this tube arrangement is to provide open passages through the

TABLE IV—CONDENSATION TESTS ON UNIT NO. 3, EQUIPPED WITH FULL GINABAT TUBE LAYOUT

Total condensing surface, 37,650 sq.ft.
Condensing surface per kilowatt, 0.941 sq.ft.
Condensing surface per cu.ft. of shell volume, 13.76 sq.ft.
Diameter of shell inside, 12 ft. 6 in.
Length between tube sheets, 22 ft. 3.5 in.
Number of tubes, 7,500.
Diameter of tubes inside, 0.787 in.; outside, 0.866 in.
Total circulating-pump capacity, 70,000 g.p.m. (in 2 units)
Circulation, single-pass.
Circulating-water velocity, 6.2 ft. per sec.

Test number	I	II
Date of test	Feb. 5, 1923	
Weight of steam condensed per hour, 1,000 lb.	249.2	385.9
Steam condensed per square foot per hour, lb.	6.62	10.25
Abs. pressure at condenser inlet, in. Hg.	0.635	0.874
Vacuum at condenser inlet (referred to 30-in. barometer), in. Hg.	29.36	29.13
Saturation temperature at inlet pressure, deg. F.	65.59	75.03
Temperature measured at steam inlet, deg. F.	65.84	75.2
Cooling-water conditions;		
Temperature in, deg. F.	39.92	40.1
Temperature out, deg. F.	48.02	51.62
Temperature range, deg. F.	8.10	11.52
Temperature head at inlet, deg. F.	25.67	34.93
Temperature head at discharge, deg. F.	17.57	23.41
Logarithmic mean temperature head, deg. F.	21.36	28.8
*Coef. of heat transfer, B.t.u. sq.ft. per deg. F, per hr.	307	353
Volume of cooling water, 1,000 g.p.m.	61	66.4
Ratio of cooling water to condensate	122	86
Absolute vapor tension of water at inlet temperature, in. Hg.	0.247	0.249
Condenser vacuum in per cent of theoretical	98.7	97.9

*Based on a heat loss of 990 B.t.u. per pound of steam condensed.

[1]The coefficient of heat transfer, and therefore the efficiency of surface utilization, were low for both condensers in these tests, because of the low temperature of the circulating water, and the resulting low degree of penetration.

tube bank. The stream of condensate flows down the top of these passages, while the steam and air flow freely through the center and come in contact at the bottom of the passage with a dry tube surface.

Fig. 2 shows a cross-section of an 11,600-sq.ft. condenser now in course of erection in a Parisian plant, the dimensions of which are:

Total surface, 11,600 sq.ft.
Surface per kilowatt, 0.775 sq.ft.
Surface per cu.ft. of shell volume, 12.7 sq.ft.
Diameter of shell inside, 8 ft. 6 in.
Length between tube sheets, 16 ft. 1 in.
Number of tubes, 3,910.
Diameter of tubes—inside, 0.63 in.; outside, 0.708 in.
Total circulating-pump capacity, 27,000 g.p.m.
Circulating-water velocity, 7.3 ft. per sec.
Circulation, single-pass.

This condenser is the result of the practical application of the lessons derived from condenser No. 6. The following features are to be noted:

The extreme width of the steam lanes at the top, tapering down almost to a point at the bottom.

The straight path open for the steam to sweep unimpeded almost to the bottom of the condenser shell.

The absence of all trace of flooding in the steam lanes or any other part of the tube bank.

The small thickness of the condenser bank, measured along the path of the steam and air.

The better utilization of the volume of the condenser shell to inclose the maximum amount of condensing surface with the minimum of crowding.

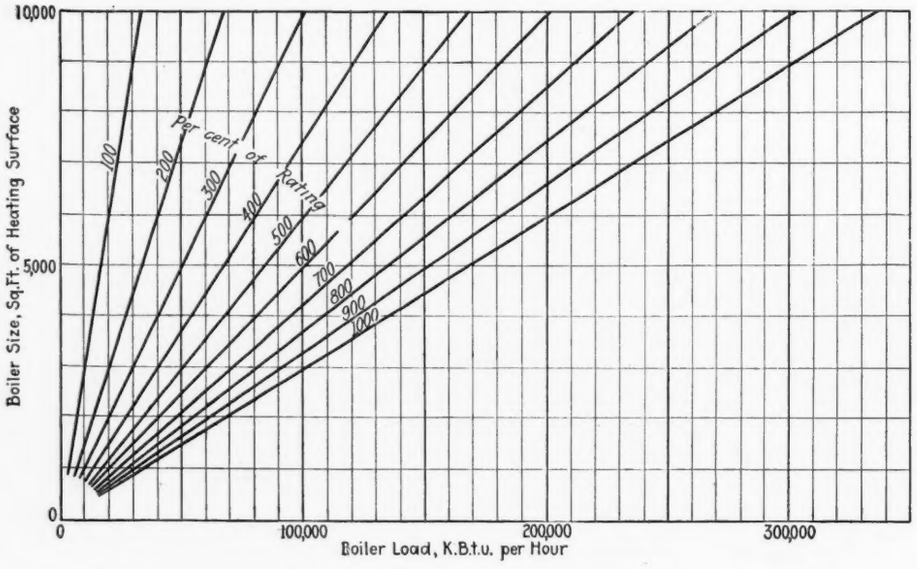
Regarding the last point, this condenser bank gives the impression of being more open in its tube arrangement than that of condenser No. 6, and appears to contain less condensing surface per unit volume of shell, whereas it actually contains 12.7 sq.ft. per cu.ft. of shell, as compared with No. 6, which contains only 10.14 sq.ft., or an increase of 25 per cent. The reason for this increase is that the large steam space above the tube bank existing in the older designs is dispensed with, and the top tubes are just below the inlet to the condenser. The object of the steam space was to facilitate the equal distribution of the steam along the full length of the bank. The great width of the steam lanes in the new condenser makes this no longer necessary, equalization of pressures along the tubes being secured by means of large openings in the support plates.

It would be premature to attempt to draw definite conclusions from the designs and performances reviewed in these articles, yet it is unmistakable that there has been a real step forward in the art of condenser design.

The author expresses his appreciation of the patient and painstaking co-operation of Mr. Rauber, superintendent of the Gennevilliers central station, and of Mr. Délas, president of the Société des Condenseurs Délas, in the preparation of this material.

Boiler Load and Rating the Old Units and the New

FOR years the size of a boiler has been stated in square feet of heating surface, and its nominal capacity in boiler-horsepower has been taken as one-tenth of this. Its actual output at a given moment or its average output for a period has been expressed as a percentage of this nominal rating.

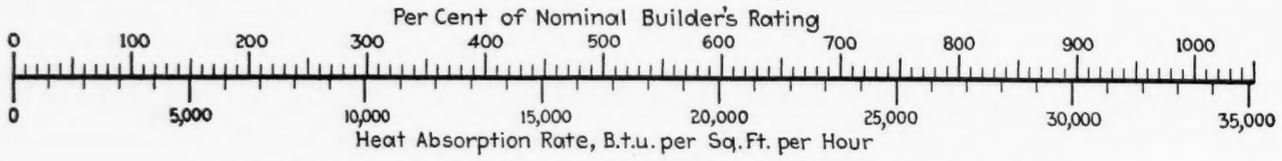


Relation between boiler size in square feet, and boiler load, in K.B.t.u. at various ratings

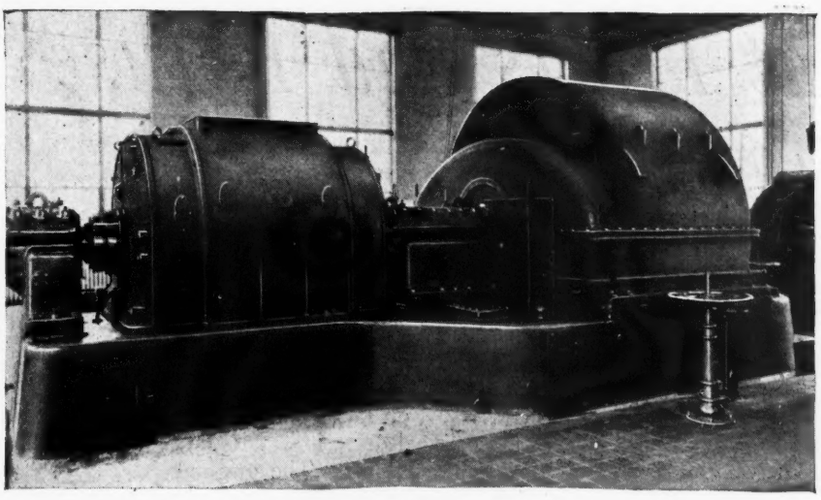
Of late engineers have come to see the absurdity of such an arbitrary rating, and there is some progress toward expressing the total load on a boiler in K.B.t.u. per hour, and its unit load in K.B.t.u. per sq.ft. per hour. This seems to be a move in the right direction.

It is perhaps unnecessary to explain that K.B.t.u. is the symbol for 1,000 B.t.u. just as kw. stands for 1,000 watts.

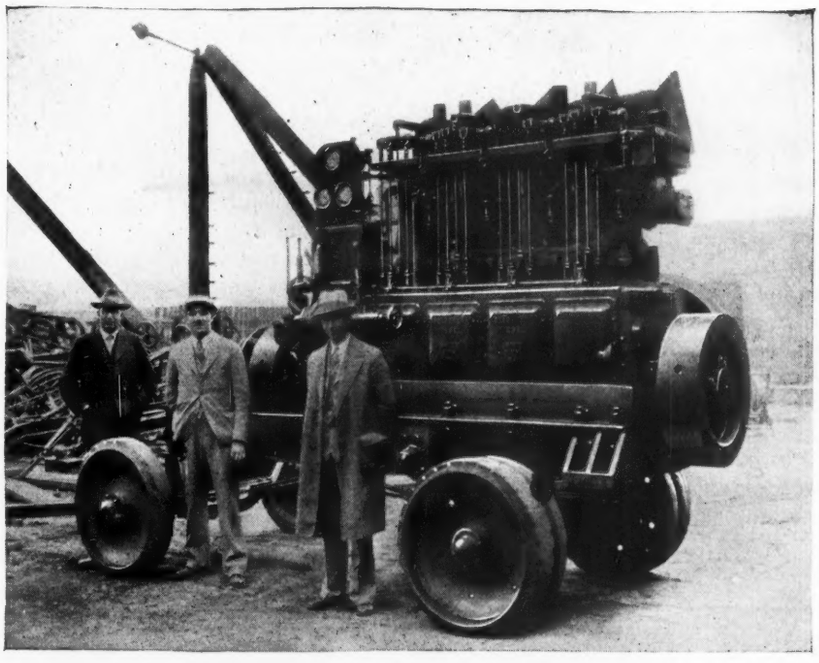
The accompanying chart and scales may assist in converting from the old units to the new and vice versa. Obviously, the scales of percentage rating and B.t.u. per sq.ft. per hour are simply the one square foot line from the chart, immensely magnified.



Relation between rate of heat absorption, in B.t.u. per square foot per hour, and per cent of nominal builder's rating



KODAKING WITH POWER



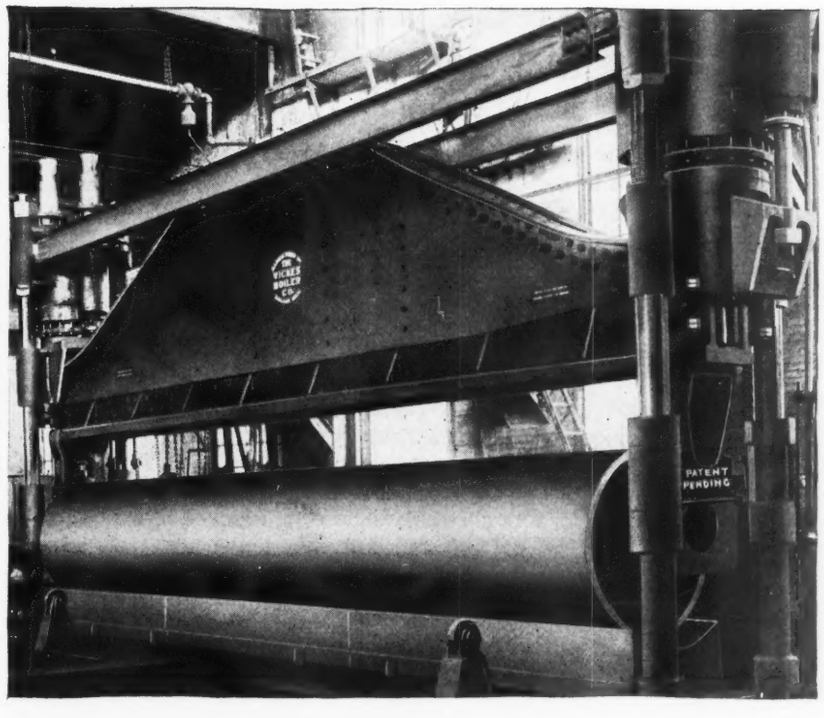


Fig. 1 (Top)—A large Ingersoll-Rand turbo-blower driven by a steam turbine

Fig. 2 (Above)—A Bessemer Diesel used as a portable power plant in the Northwest

Fig. 3 (Right)—A 30-ft. hydraulic press used by the Wickes Boiler Company

Burning Oat Hulls and Refuse in Powdered Coal Furnaces

By C. J. Herbeck

Chief Engineer, Cedar Rapids Plant, Iowa Railway & Light Corporation

OWING to market conditions some time ago, it was necessary for the Quaker Oats Company to dispose of the oat hulls left as a byproduct from the making of oatmeal, and it was decided to burn them in the power station of the Iowa Railway & Light Corporation at Cedar Rapids. Not having had any experience in burning fuel of this kind, the operating force was at a loss to know how to proceed, particularly as it was required to burn in the neighborhood of 300 tons in 24 hours. Analyses of the hulls showed that they contained from 6,500 to 7,000 B.t.u. per pound. They were bulky, and in order not to tie up too much of the boiler capacity, it was necessary to burn a large volume of the hulls per boiler.

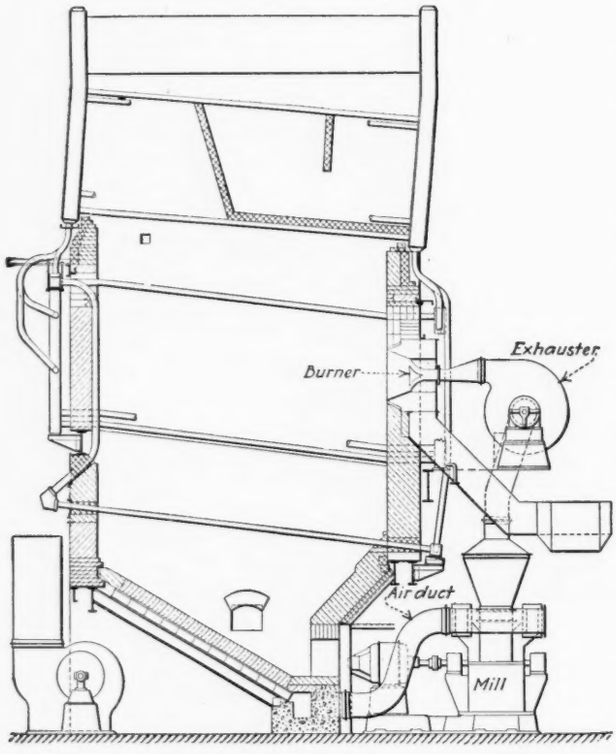


Fig. 1—Section through powdered-coal installation

First, chain grates were given a trial, but with the boiler units allotted for burning this fuel it was found that they would not burn the required amount. Numerous experiments to increase the burning capacity resulted in other difficulties.

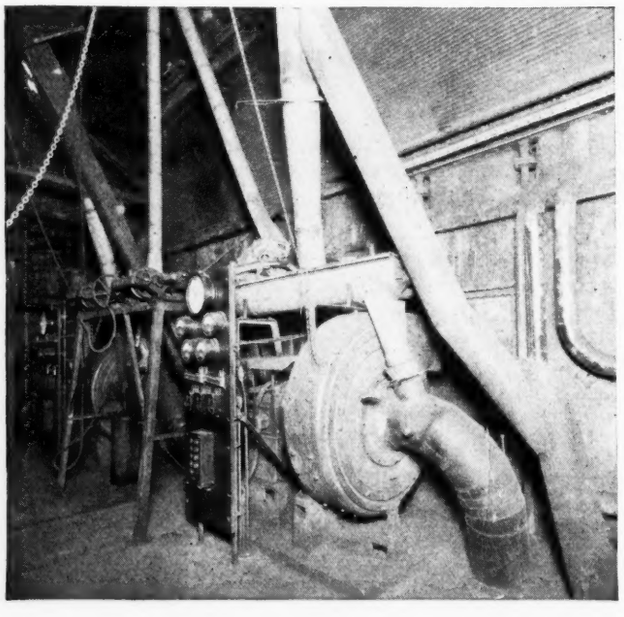
To deliver from the Quaker Oats Company the amount of oat hulls previously given, required three closed trucks. Later on, a pneumatic blower was installed and the hulls were delivered through an 8-in. underground pipe into the original coal bins through a cyclone for disposing of the dust. As the distance between the two plants was approximately 1,200 ft., this new method was more flexible and less expensive.

Use of this fuel on underfeed stokers was next tried, but with the original drive it was impossible to burn the required volume of hulls. The original drive was disconnected and the plungers connected directly to the crankshaft. The speed of the shaft was increased to 5 r.p.m. With this method of driving it was impossible to operate all the secondary pushers, so every other pusher was disconnected. In this way a considerably greater volume of fuel could be burned, but with little better results than on the chain grates, and the nuisance created from particles of unburned hulls passing out of the stack became so disturbing to the city that steps had to be taken to eliminate it.

By chance it was discovered that during the time the soot blowers were in operation, practically all the smoke from burning the hulls was eliminated. Another analysis of the hulls showed that approximately 70 per cent of the combustible was volatile, so arrangements were made to admit under pressure the larger proportion of air for combustion over the fire. This method worked out satisfactorily, but it was still felt that better results could be obtained, and further experimentation proved that burning the hulls in suspension was much the better way.

Two boilers were equipped for burning powdered coal, the pulverizers being in the basement and the exhausters on the boiler-room floor, so that the latter would discharge directly into the furnace. This equipment burned the oat hulls, and during the seasons of the year when

Fig. 2—View of boiler fronts, showing individual oat-hull feeders delivering into suction pipes of exhausters



other uses could be found for the hulls, powdered coal was the fuel. Naturally, this arrangement was more flexible, as a change could be made from one fuel to the other with no outage. This was not true with the underfeed stokers, for to change them back for burning coal required taking the boilers out of service.

Some difficulty at first was experienced in controlling the feed of the hulls. From the bunker they were fed through the same spout that had been used for coal, to the mill, until it was discovered that the suction on the mill varied the feed. The individual feed for the hulls shown in the accompanying photograph, then was installed. From the feeder connection was made directly to the suction of the exhauster and the mill shut down to reduce the power requirements. It is now possible to burn oat hulls intermittently without difficulty and with good results.

Another interesting function of this powdered-coal equipment is to burn certain refuse that it is necessary to dispose of during the periods that other uses are found for the oat hulls. By a partition in the coal bunker this refuse is kept separated from the coal. It is fed through the individual feeders and burned along with the powdered coal. By adjusting the feeder, it is easy to control the amount of refuse that can be burned without affecting the capacity of the boiler.

Letters from an Oil Engine Operator

Remarks on a Smoky Exhaust

Dear Ed.: Here you have written and told me that your engine smokes at the exhaust, that it is not caused by the fuel valves, nor the fuel pumps, nor the time of injection. You say it is not overload and that the exhaust pipe is clear and the air-inlet breathers are clean. You say you have checked every possible reason for smoke, even going so far as to remove the valves and examine the inside of the cylinder heads for deposits of carbon, and that you have checked up on the condition of the water jackets to make sure no scale has formed to make the cylinders excessively hot and reduce the volumetric efficiency through expanding the air as the engine takes it in.

I do not question the manner in which you have made your investigation. I would have done the same thing, but I would never say as you have said, that the trouble cannot be found—for it can. You have made the routine search and have covered such items as experience in the operation of previous jobs has taught you to do, but you have overlooked one important bet.

When you first took your job, you wrote and told me that the outstanding success with the system of combustion employed in your engine was due to the peculiar cylinder-head shape and the excellent turbulence thereby obtained.

About three weeks ago you wrote and told me you did not like the way the air-inlet breather pipes were put on the engine and you had changed them to an upright position, which would give more room about the engine, and now you write and tell me that you have been trying to chase down gray smoke at the exhaust for the last three weeks.

You should not have changed those breather pipes. Don't you suppose that the engine builder has been reminded of the fact that they are in the way and do you think that he has not tried to alter them to a more convenient position? They had to be put on in that position to give the correct flow of air into the cylinder, not the correct amount of air. He has probably tried to change the cylinder-head design to get them out of the way, and each time he made a change he has interfered with turbulence. The construction of this cylinder head and the success with this system of combustion are the result of many experiments. He finally hit upon an arrangement of air and exhaust passages which will set up currents of air that sweep the combustion space in exactly the right way to bring about perfect combustion.

You changed the breather pipes because they were in your way, and while doing it probably remarked to yourself that all engine designers were dumbbells and that this one in particular was king of the lot.

You have been trying for three weeks to eliminate smoke which appeared at the exhaust as soon as you changed the breather pipes, but with your mind set upon the one idea that air is air, it has never occurred to you to put them back as you found them.

If you put them back the way they were, I will bet a box of cigars that your smoke will clear up. In the meantime you have the engine adjusted nicely, fuel valves all overhauled, fuel pump in excellent condition and there is that much of your routine work done in advance.

Now Ed., old timer, I have talked wise and you may think I am a regular Sherlock Holmes in the solution of engine mysteries. Such is not the case. I am a big bluff. I tried the same thing on one of those engines, and the blamed thing smoked until a service man from the factory blew in one day and told me to change the breather pipes back if I wanted to get rid of the smoke. He said the chief engineer told him about it.

Good luck with your smoking exhaust.

Sincerely, E. O. Leseid.

Reversing the Seasons

In the early days the oil refiner in Pennsylvania processed the crude oil only in winter, as a low temperature was needed to throw down the wax. The modern oil man must travel at a swifter pace, so, as N. H. Hiller points out in next week's issue, the refiner has turned to the refrigeration engineer for the artificial winter he must have the year around. Here again refrigeration plays an important role in American industrial life.

WATER-STAGE RECORDS

Improve

Hydro-Electric

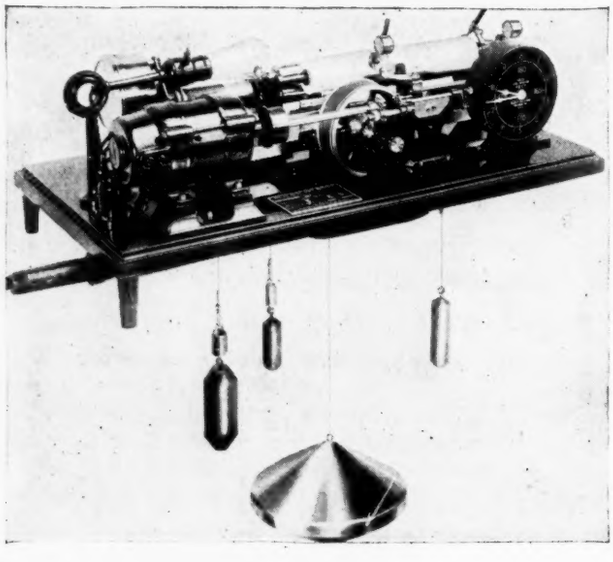
Plant Operation

Experience at the Holtwood Plant of the Pennsylvania Water & Power Company, with records of forebay and tail water levels

FOR the economic operation of water-power plants, pumping stations and other hydraulic works it is important to have accurate information concerning the quantity and variation of the water supply. To obtain this information, water-level recorders giving a graphic record of stage are coming to be a standard part of the equipment in connection with all works that utilize the water of surface streams. These records of stage are of direct use in the daily operation of the plant. They are also of much value in studies leading to more economical use of the water available and improvements in operating conditions.

Fig. 1—Type of water-level recorders and transmitter located at the tailrace and forebay

On the recorder is a selsyn motor, the rotor of which is rotated by the movement of the float in the water. This selsyn motor is connected to one in the indicator on the switchboard. As the recorder selsyn rotor turns, the rotor of the indicator and the pointer are moved to show the water level. Since the indications are transmitted electrically, they can be sent almost any reasonable distance.



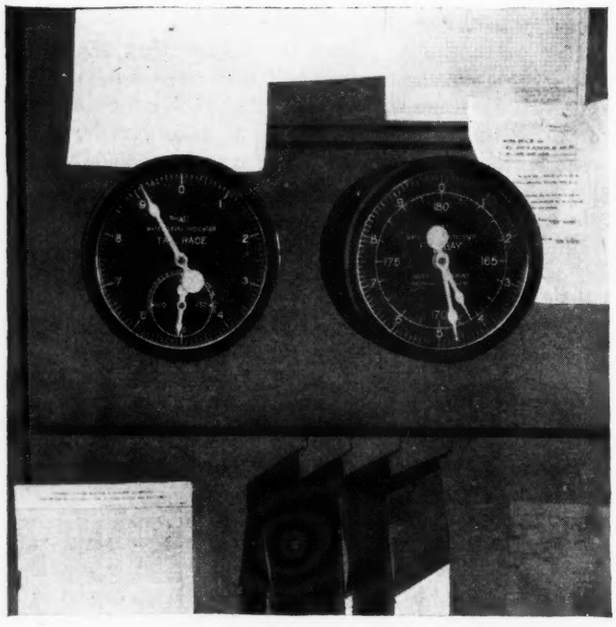


Fig. 2—Tailrace and forebay water-level indicators on the power-house switchboard

At the Holtwood plant of the Pennsylvania Water & Power Company two Au recorders with distance indicators, similar to those shown in Figs. 1 and 2, have been in operation for about a year. These recorders and indicators were designed by Carl H. Au, mechanical engineer, Washington, D. C., and were manufactured by Julien P. Friez & Sons, Baltimore, Md. One of the recorders is in the forebay about 600 ft. from the operating room; the other one is in the tailrace directly under this room. Fluctuations of stage from both recorders are indicated on dials on the operating board, as shown in Fig. 2. Varying conditions of the power-plant draft are immediately reflected in the graphs obtained by these two recorders, as indicated on the typical recorder sheets shown in Figs. 3 and 4.

The conditions at the Holtwood plant are somewhat exacting, as an error of 0.1 ft. in the record made in the forebay during moderately low water will make a difference of 5 per cent in the determination of the river flow. Accurate records of stage are therefore required both in the forebay and in the tailrace. Furthermore, as the plant is operated in connection with steam plants, it is essential to have accurate information as to the exact amount of hydro-electric power that can be furnished at all times. Among the advantages gained by using the recorders and indicators at the Holtwood plant are the following:

1. The tailrace recorder has made possible the development of tailrace rating curves showing the effect of changed conditions. Formerly, operation of the plant depended on staff-gage readings, with no measure of their reliability or of the steadiness of conditions at the time of reading or even any great assurance that the readings were taken on schedule time. By means of the recorder it is possible to eliminate all readings except those taken when conditions are steady, so that dis-

crepancies between the individual readings can be greatly reduced.

2. The reduction of the discrepancies showed that the rating curve, which had been assumed to be a single curve concave downward, actually had a reverse bend, indicating a shift of control. This information has led to excavation to remove the constriction causing the

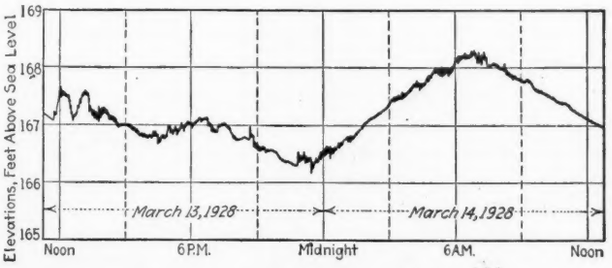


Fig. 3—Twenty-four-hour record of forebay level

The conditions at the Holtwood plant are somewhat exacting, as an error of 0.1 ft. in the record made in the forebay during moderately low water will make a difference of 5 per cent in the determination of the river's flow.

shift, and this work has resulted in increased head, giving a material saving in energy. The accurate determination of the rating curves not only led to the excavation work to remove one constriction, but they also made it possible to determine fairly accurately the gain resulting from a comparatively small expenditure. By the use of the accurate record obtained on the recorder there was no difficulty in showing that the expenditure of a few thousand dollars would easily pay for itself within two years, while in work done several years previously staff-gage readings showed no benefit until a large expenditure had been made.

3. The use of the forebay chart showed the presence of hourly surges that had not hitherto been suspected, as

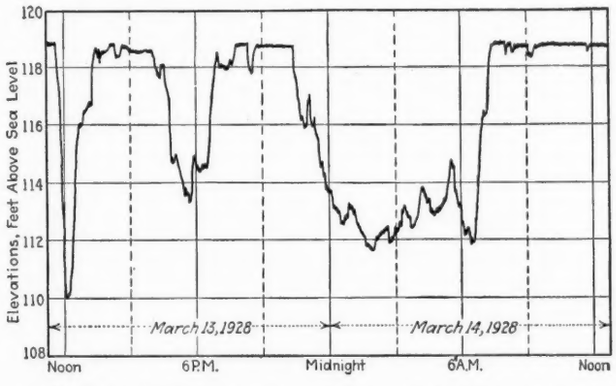


Fig. 4—Twenty-four-hour record of tailrace level

By the use of accurate records of the tailrace level it was possible to show that a small expenditure to remove an obstruction in the tailrace would easily be saved in two years, while in work done several years ago, staff gage readings showed no benefit until a large investment had been made.

indicated in Fig. 5. These surges are caused apparently by sudden changes in the amount of water passing through the power plant. Each surge travels the length of the forebay and returns in almost exactly one hour. This wave is amplified particularly in the afternoon on account of the fact that it is set up by the sudden drop in load at noontime and is given a second impulse by a sudden regain in load one-half hour later, just as the surge reaches the upper end of the pond and is ready to return. These variations produce disconcerting effects upon the estimate of river flow, since much depends upon the part of the wave that happens to be read by the operator on his regular hourly rounds. The possession of a graphic record of the forebay has led to the development of a method of overcoming the effect of these surges.

4. The long-distance indicators from the recorders to the benchboard are of advantage in enabling the load dispatcher to control the load on the plant to bring the forebay every morning to the most economical level. A comparison of maximum forebay readings made in the season before and in the season after installation of the transmitter shows a marked improvement in this respect.

5. Formerly, the forebay and tailrace readings were read by the machine man from staff gages, and the plan of operation required that the forebay gage be read exactly on the even hour. At this time it was desirable to have the machine man at the switchboard to assist the other operators with the necessary meter readings, etc. With the distance indicators the forebay may be read at

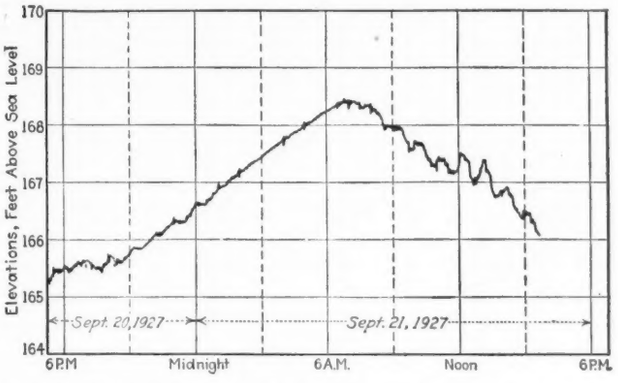


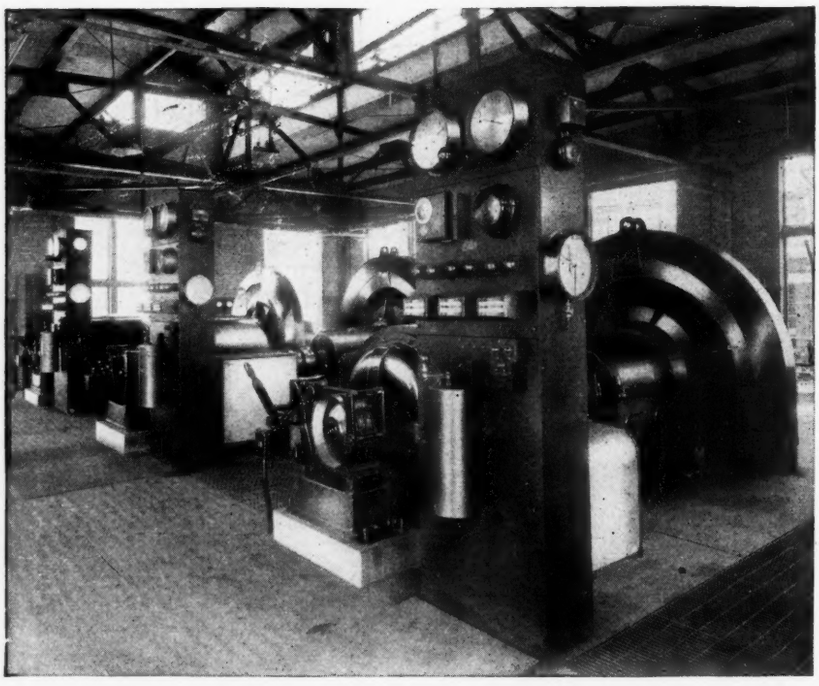
Fig. 5—The use of forebay records showed the presence of hourly surges that had not hitherto been suspected

the board before the machine man makes his regular rounds of inspection.

6. By having the forebay indicator on the benchboard, it is possible to telephone the information to the load dispatcher about a quarter of an hour earlier than previously. Having this information in advance, the load dispatcher has this amount of additional warning in case it is necessary to make radical changes in the steam schedule on account of a sudden rise in the river. The additional revenue which may be gained at such a time by having this information fifteen minutes earlier may amount to as much as $60.

7. The transmission from tailrace to benchboard in this plant is practical only by electrical means, inasmuch as the available space is so congested with equipment and conduits that it would have been impossible to obtain direct mechanical connection to the float.

8. On one occasion last summer, before the forebay indicator had come to be relied upon, an operator made a mistake in reading the old type of staff gage. This mistake led to a false determination of river flow and by a strange coincidence led to a chain of unfortunate circumstances which cost the company several thousand dollars. The danger of being misled again by a mistake in reading is much reduced, inasmuch as the load dispatcher can call back and get a check reading without its being necessary to make the machine man take a special trip to the forebay staff gage.



The equipment on the control panels is designed to be explosion proof

MULTI-SPEED MOTORS

Drive Gas Boosters

By A. Kling

Industrial Control Engineer, General Electric Company

THERE has been a growing demand for large squirrel-cage motors having such characteristics that they may be started on full-line voltage. Chief among the reasons contributing to this demand is the simplicity of the control equipment and the lower cost, both first cost and service cost. The saving in space required for the control is also often an advantageous factor.

The problem of gas distribution requires widely varying pressures to meet the changes in daily and seasonal demand. Although a variable-speed motor has been considered the best form of driver under such conditions, the results so obtained can be closely approximated with a multi-speed squirrel-cage motor. This motor has the advantage of being sturdy in construction, more efficient at lower speeds and free from sparking contacts, thus greatly reducing the danger of explosion from gas leaks. Furthermore, when the motor is designed for full-voltage starting, the advantages mentioned also apply to the control.

> The boosters are single-stage centrifugal compressors driven through speed-increasing gears by multi-speed squirrel-cage motors. The motors are free from sparking contacts thus greatly reducing the danger of explosion from gas leaks. This would also apply to any kind of a plant requiring centrifugal compressor drives in the presence of explosive hazards.

Such an arrangement covering a complete gas-booster equipment was recently supplied to the Consolidated Gas Company, of New York, to be installed in its Hunts Point Station, shown in the headpiece and Fig. 2. The boosters are single-stage centrifugal compressors, driven through speed-increasing gears by three-speed squirrel-cage motors rated at four, six and eight poles, 1,950, 580 and 265 hp., when operating at 1,800, 1,200 and 900 r.p.m. respectively. These motors operate on 2,300-volt three-phase 60-cycle power. The compressor capacities at the three speeds are as given in the table.

The control equipment is designed for starting the motor on full-line voltage at any one of the three speeds. Direct-current solenoid-operated oil circuit breakers are used for connecting the alternating-current lines to

the proper terminals of the motor for any given speed. Four breakers are required for this purpose: Two with three-poles for making the high-speed or four-pole winding connection, one with four poles for making the intermediate or six-pole winding connection, and one three-pole breaker for making the low-speed or eight-pole winding connection.

These circuit breakers are controlled from a three-point master switch which is so designed that, when set in one position, it actuates the trip coils for the breakers which operate in the other two positions of the master

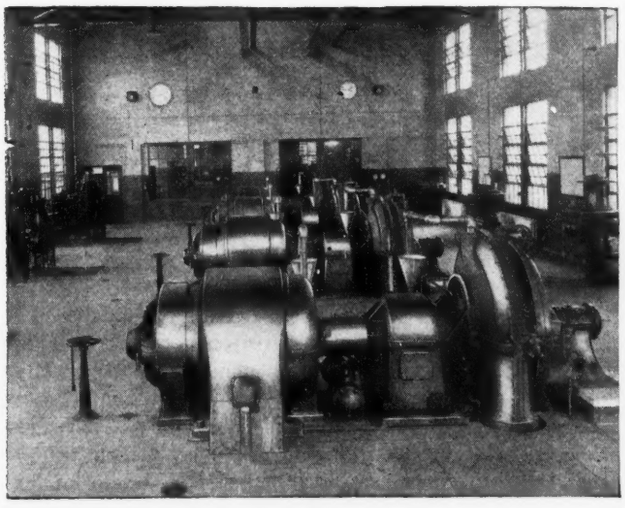
COMPRESSORS' RATINGS AT THREE SPEEDS

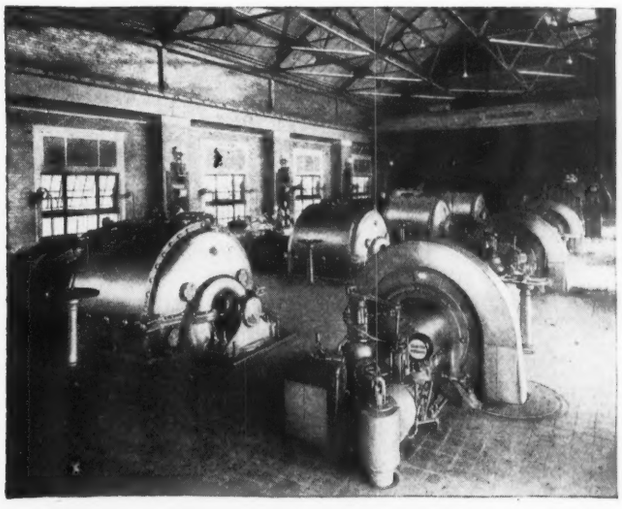
Inlet Volume, Cu.Ft. per Min.	Gas Pressure, Lb. Gage	Compressor Speed, r.p.m.	Motor, Hp.	Motor Speed, r.p.m.
54,000	6.5	6,550	1,950	1,740
36,000	3.0	4,370	580	1,160
27,000	1.8	3,260	265	865

switch. When the master switch is moved to the off position, it energizes the trip coils of any breakers that happen to be closed. As a further protection against the closing of more than one line breaker at the same time, the closing coils of the breakers are electrically interlocked in a manner that requires that all breakers be open before the closing circuit of any breaker can be energized. On overload or undervoltage the trip circuits of all breakers are energized. The overload relay is a thermal device having a characteristic designed to give the motor protection against overheating. Only one relay is used, the correct calibration for the different speeds being obtained by choice of the proper current transformers.

The motor is fitted with a manual release friction brake for holding, to prevent the equipment from running backward when power is off. A normally open interlock in this brake makes it necessary for the brake to be released before any of the breakers can be closed, and this interlock also causes all the trip circuits to be energized if the brake should set. Since the brake is designed for holding only, it must not be allowed to set as soon as power goes off, but must be retarded until the equipment has almost reached a stop. This retarding feature is introduced by controlling the brake from a pressure switch operated by the lubricating oil pressure, such pressure being proportionate to the speed of the equipment. Thus it is possible to set the pressure switch to trip the brake when the machine is running at a very low speed.

It is necessary to release the brake before the motor can be started, this also being safeguarded by electric interlocking. To prevent the immediate resetting of the brake, a definite-timing relay is incorporated in the trip





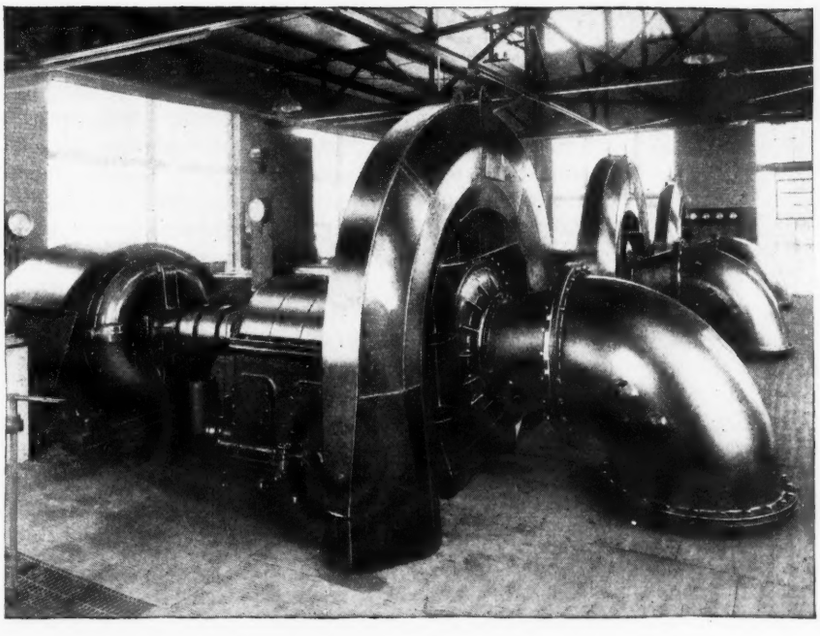


Fig. 1 (Upper Left)—Four centrifugal gas boosters driven through speed-increasing gears by 950-hp. variable-speed induction motors

Fig. 2 (Left)—Three centrifugal gas boosters driven through speed-increasing gears by multi-speed squirrel-cage induction motors rated at 1,950, 580 and 265 hp. when operating at 1,800, 1,200 and 900 r.p.m. respectively

Fig. 3 (Upper Right)—Four centrifugal gas boosters and three exhausters driven by steam turbines

circuit of the brake in such a way that the pressure switch is ineffective until the time relay has operated. The time relay is set just long enough to allow the oil pressure to build up. This timing feature also affords protection against failure of the lubricating oil system and against the possibility of a careless operator's releasing the brake but failing to start the motor. The function of the time relay is independent of the motor starting. The timing operation begins when the brake is released, and when it ends the brake will trip unless the oil pressure is up.

Operator's Information System

Besides the actual operating features there is included a system for informing the operator when a change in speed should be made, and also whether the change should be in the nature of an increase or a decrease. There are three contact-making ammeters, one for each speed. These are calibrated to cover the load range recommended for the particular speed. Each contact-making ammeter controls two relaying contactors, one of which operates at the higher setting and lights a green lamp to indicate that an increase in speed should be made; the other operates at the lower setting and lights a red lamp indicating that the speed should be reduced. Each of the contactors has another circuit, and all of these are wired in parallel to ring an alarm bell and summon the operator when any of the lamps light.

Another timing relay is used here to keep the control circuit for the relaying contactor open until the motor is started and the current has had time to become stable in the circuit.

Most of the equipment, including the oil circuit breakers and the contactor panels, is mounted in a separate switching room. It was necessary, however, to mount some of the apparatus in the booster room, where there is a possibility of exposure to explosive mixtures of gas. As a precaution against explosion it was necessary to use an oil-immersed master switch, a tight-gasketed cover for the pressure switch, vapor-proof indicating lamp fixtures, and an alternating-current alarm gong which has no make-and-break contacts. This equipment is shown all mounted on pillar supports, together with three indicating ammeters, in the headpiece. The scales of the ammeters also have a volume calibration in cubic feet per minute.

Care of Collector Rings and Brushes on Induction Motors

By D. F. Alexander
Industrial Motor Engineering Department
Westinghouse Electric & Manufacturing Company

FOR reliable and uninterrupted operation the brush-holders and brushes on industrial motors require frequent attention. This is especially true where the motor is exposed to excessive dust, scale or acid fumes. Frequent cleaning is a cheap form of life insurance for all motor insulation, including that of collectors and brush rigging. The dust from brush wear is of high conductivity and must not be permitted to form a coating on the surface between the brush-holders or collector rings. Unless the surfaces are kept clean, an arc over may result, making the insulation unfit for service or in severe cases destroying the metal parts.

A close check should be made to see that the brushes fit properly, that the shunts are tightly connected, that the spring pressures are uniform, and the rings are round. In the case of collector-ring brushes any sparking should be immediately investigated. Care should be exercised to apply graphite and metallized-graphite brushes correctly; one should not be applied in place of the other.

The brushes should be checked frequently to see that they fit properly in their boxes. They must be the correct size, neither so loose that there is appreciable rocking when the motor is reversed, nor so tight that they bind in the holders. Dirt must not be allowed to collect on the sides of the brushes. At periods of inspection each brush should be worked up and down in its holder and the machine should not be placed in service until all brushes slide freely.

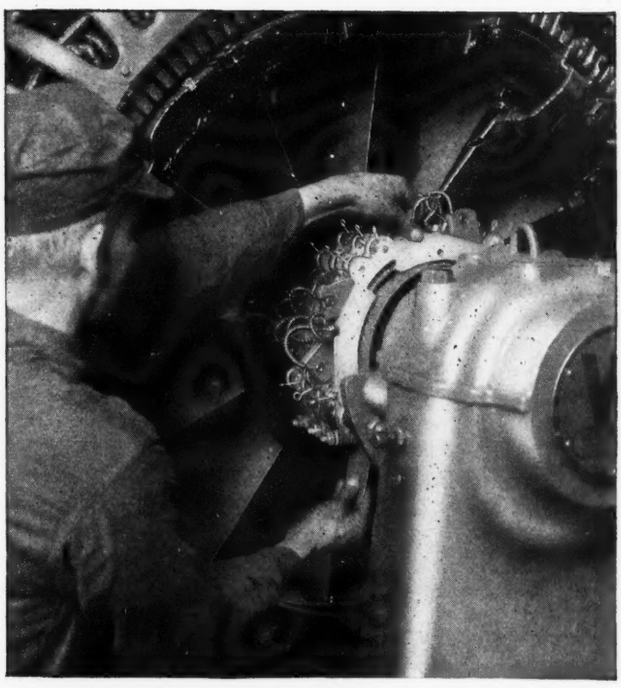
It is well to check the shunts, particularly at the connection to the brushes. Poor or loose connections of the shunts result in the brush-holders becoming the current conductors and may cause arcing or burning in the brush-holder boxes. Pitted brushes or boxes usually indicate poor shunt connections. If brush shunts are loose or broken, immediate replacement of the brushes may avoid injury to the brush-holders, which might shortly necessitate replacement of the entire brush-holder assembly.

Uniform Spring Pressure

Of equal importance is a uniform spring pressure on the brushes. Otherwise the current will not be evenly distributed. The brushes with the greater spring tension will tend to take more than their share of the current. In such cases certain brushes may carry several times the average value of current and permanent injury result from overheating. The proper spring tension for metallized brushes is 3 to $3\frac{1}{2}$ lb. per sq.in. of contact surface, and for graphite and electro-graphite brushes a spring tension of $1\frac{3}{4}$ to $2\frac{1}{2}$ lb. per sq.in. is used. In measuring this tension corrections should be made for the weight of the brush according to its position on the ring. A spring that has lost its temper through overheating should be replaced.

If brush-holders are imperfectly centered, so that a part of the brush overhangs the edge of the ring, causing a lip to form on the brush, the rate of brush wear and the dusting increases. If it is impracticable to avoid this condition, the overhanging edges of the brushes should be kept carefully beveled off.

The care of the rings is quite as important as that



The brushes should be fitted carefully to the rings and move freely in their holders

of the brushes, and in many cases trouble can be attributed to the lack of this care. A ring that is rough or eccentric will prevent good contact being made, particularly at high peripheral speeds. Vibration naturally produces similar results. Rough or eccentric rings should be turned or ground, and causes of vibration should be eliminated.

Even in the best of balanced high-speed machines the vibration is sufficient to cause appreciable variations in contact pressure, and for this reason it is standard practice to employ two or more brushes per ring located at different points on its circumference. If any one brush tends to leave the ring, the others may remain in contact to carry the current.

Collector Rings for Heavy Current

Collector rings for heavy-current duty require leads to them having a large contact surface, usually held in place to the ring with tap bolts. Such bolts, and all bolts and nuts at the junction with the leads from the rotor, should be kept tight.

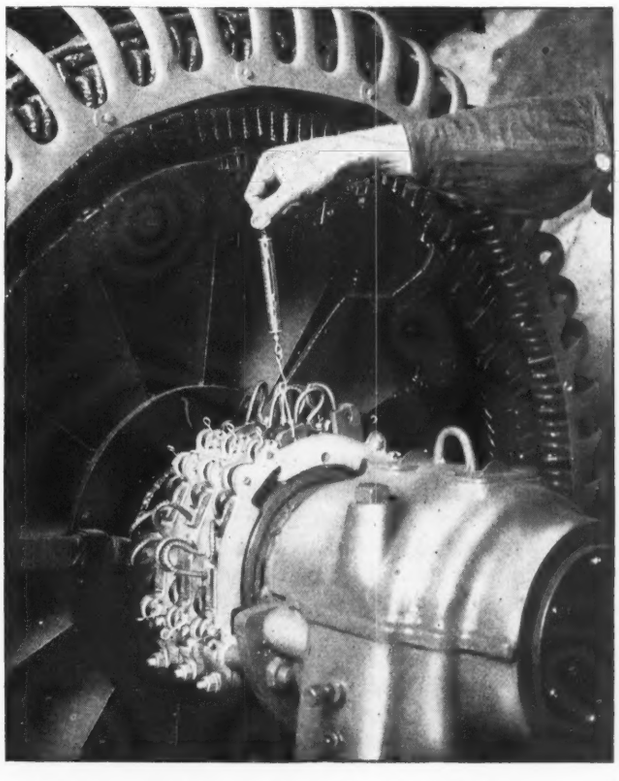
With collector-ring brushes any sparking must be regarded as serious. With metal-graphite brushes sparking has the tendency to burn out the metal from the contact surface leaving the graphite, as a result of which the voltage drop may increase to several times its normal value, the losses increase, and the current distribution become disturbed so that the effect is more or less cumulative. Cases of this sort have been found where the operation of some of the brushes of a machine has been seriously impaired, and in some instances their effectiveness as brushes has been entirely destroyed.

When sparking, or even evidence of certain brushes getting hot is first observed, all brushes should be inspected and any exhibiting a blackened contact surface or foreign particles embedded in the surface should be scraped until the original brush color appears. It may be mentioned that this effect varies considerably in various grades of brushes; in some it is practically negligible, while in others it is a serious matter demanding attention.

Both carbon (graphite) and metallized-graphite brushes are used for induction-motor service. For the smaller motors having small values of current to be handled, the carbon brush is a cheap and satisfactory type. For large motors, however, the use of a metallized-graphite brush makes possible an increase of about 50 per cent in brush current density without an increase of temperature. Although the metallized-graphite brush is not recommended for all applications, it is well suited for large induction-motor service, where a greater range of characteristics is permissible than for other types of machines requiring current collection.

It is important to know that brushes of lower current-carrying capacity should not be substituted for the grade originally furnished. In replacing some of the brushes different makes or grades of brushes should not be used on the same motor. Unequal current division between brushes would result, probably with damage to the brushes carrying high currents. In emergency, where there are no like brushes available, the brushes for any one collector ring should be kept alike, giving equal current division between brushes for each ring.

If the foregoing instructions are followed, they will do much to prevent troubles that have been experienced with the collector rings and brushes of some machines. Some maintenance men are inclined to the attitude that, since collector rings present a continuous surface to the brushes, they are not so likely to give trouble as a commutator that is made of segments and has to commutate the current in the armature coils. This attitude is likely to lead to trouble since, as shown in the foregoing, there are many things that can cause trouble with collector rings and their brushes.

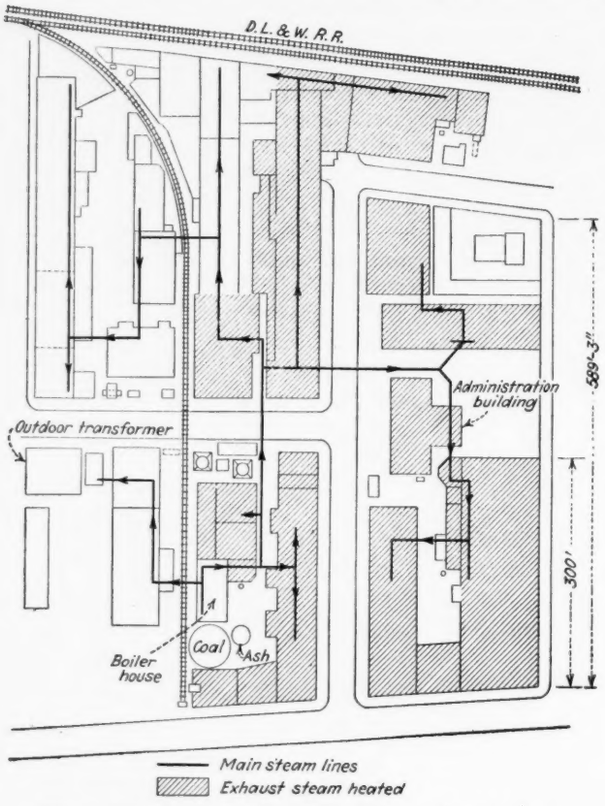


The spring tension on the brushes should be measured with a scale and an allowance made for the weight of the brush according to its position on the ring

Chain Grates Replace Oil Burners

The Manhattan Rubber Manufacturing Company saves $53,000 annually by burning anthracite coal instead of oil

THE Manhattan Rubber Manufacturing Company, Passaic, N. J., is engaged in the manufacture of mechanical rubber goods, such as hose, belting, brake lining, molded goods, etc. The vulcanizing processes are carried out largely by the use of steam, which is employed for heating hydraulic presses and vulcanizers. Steam is also used to drive various high-pressure hydraulic pumps and air compressors. During the winter months exhaust steam from the hydraulic pumps, air compressors and boiler auxiliaries is used for building heating as well as for heating boiler-feed water. Sufficient exhaust steam, however, is not available for heating all the factory buildings, and is supplied only to those buildings shown cross-hatched in the property plan, the remainder of the buildings being heated with live steam.



Plan showing buildings heated by exhaust steam

On the property plan are also shown the steam distribution mains to the various buildings. Between buildings the mains are laid in 6 ft. wide by 6 ft. high tunnels which provide ample space for whatever maintenance work may be required on them.

Prior to two years ago the boilers supplying the steam were oil fired. The steadily increasing cost of fuel oil suggested that considerably cheaper steam might be produced if the oil burners were removed and coal-burning equipment installed. A careful study of the situation made it evident that the savings obtainable through this change would soon pay for the cost of the new equipment necessary.

The change over from fuel oil to coal was made on one boiler at a time and was completed in July, 1926. The two years' operation has fulfilled all expectations.

The present boiler plant contains four horizontal water-tube boilers each containing 6,650 sq.ft. of heating surface, in which steam is generated at 150 lb. pressure. Fuel is received by rail and dumped into a track hopper from which a Manhattan rubber belt conveyor delivers it to a bucket elevator. This elevates the coal and drops it either into an auxiliary bunker that supplies a traveling larry in the boiler room, or into a large circular concrete bunker outside the boiler-house building. When it becomes necessary to use the coal stored in the concrete bunker, gates at the bottom of it may be opened and the coal delivered by gravity to the bucket elevator, which carries it to the auxiliary bunker feeding the boilers.

Anthracite was felt to meet the local conditions best, as the plant is situated on an anthracite railroad. Accordingly, a Harrington chain-grate stoker having a grate area of 117 sq.ft. was installed under each boiler. These stokers, designed for burning No. 3 buckwheat, are engine driven and permit operation at 150 per cent rating.

It was necessary to rebuild a large part of each boiler setting in order to permit the construction of ignition arches. Both the front and the rear arch are of the double suspension type, with a throat width of 30 in. The walls of the furnace are air cooled and are lined where necessary with carborundum bricks.

Ashes from the hoppers at the end of each stoker are dumped into a handcar which is rolled on tracks to a pit in which is an ash hoist car. This elevates the ash to an outside concrete bunker from which it is removed by motor truck.

In the boiler-room basement is installed a double-inlet engine-driven fan of 60,000 cu.ft. per min. capacity, which delivers air to all four stokers. A smaller fan in the basement is used during periods of low steam demand.

An automatic system of combustion control, actuated by the boiler pressure, regulates the stoker and blower engines and controls the boiler dampers. A steam-flow air-flow meter on each boiler helps the firemen to maintain efficient combustion conditions.

No economizers or air preheaters are installed. A concrete stack 11 ft. in diameter and 225 ft. high is supported on the building steel.

Feed water is about 50 per cent makeup from the city water mains. It is treated with soda ash, heated to 209 deg. F. in an open heater, and delivered to the boilers by steam-driven centrifugal boiler-feed pumps. Reciprocating steam pumps are available for emergency service.

The cost of steam per 1,000 lb., including coal, labor, water and supplies but exclusive of maintenance and overhead charges, averaged 23.7c. for the year 1927.

When the oil-burning equipment was in operation, between 13.5 and 14 lb. of steam was generated per pound of oil, and the cost of steam was about 40.7c. per 1,000 lb. With a steam generation of about 350,000,000 lb. per year an annual saving of about $53,000 has resulted from the use of anthracite instead of oil fuel.

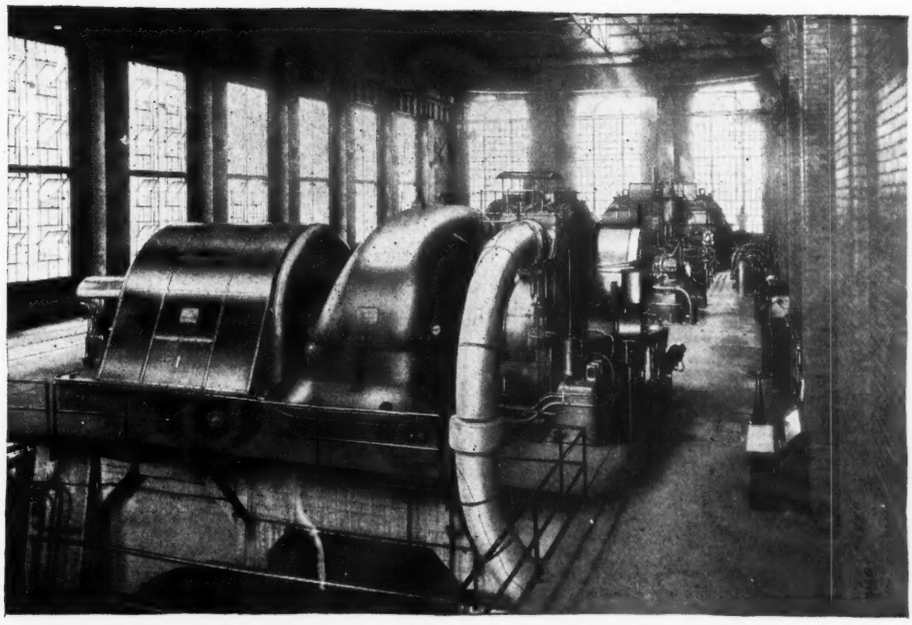


Fig. 1—Acme Station of the Toledo Edison Company

REGENERATIVE CYCLE

Saves 10 Per Cent

In Acme Station

By E. L. McBee

Assistant Superintendent of Production
The Toledo Edison Co.

IN GENERAL, modern steam-electric power plants show quite clearly in their design the influence of territorial location and the nature of the load they serve. The will of the designers and the management, of course, is in the picture, but the choice is ruled in general by external conditions bearing on the construction and use of the plant. Whether the neighborhood of the plant site be residential, industrial or sparsely settled, the conditions governing fuel supply, water supply, foundation strata and cost of foundation space, and the nature of the load demands to be served by the station, are factors that mark the general pattern of a steam-electric plant.

If the plant serves a large, rapidly growing metropolitan center and is an addition to a group of plants serving this center, it is designed and built to complete ultimate capacity as designed in a relatively short period of time. In all probability like parts will be duplicate and interchangeable and identical in operation, all matters of considerable advantage in the security of service and economy of construction and operation to a refined degree. Or, if it is a large plant, the generating units may be of the large compound type, perhaps unlike each other, but each with its boilers and auxiliaries complete within itself and forming a plant within a plant. Thus the giant plants are molded by the tremendous demands they are to satisfy.

At the other end of the scale is the small or moderate-sized steam-electric plant serving a complete but smaller unit of territory in which growth of demand is much slower. The development of this plant, perhaps to a greater degree than any other, is ruled by the course of the increase in demand in its territory, because the plant's development will spread over a period of several years. The heat cycle and equipment of the large plant may be designed and constructed as a whole, while for the slowly growing plant they must be fashioned in a series of additions to existing equipment.

The Acme Station of the Toledo Edison Company is one of the moderate-sized plants developing over a relatively long period of time and changing from the Rankine to the regenerative cycle. This plant was designed in 1916 and the first unit placed in service early in 1918. The principal initial equipment consisted of a 20,000-kw. turbine generating and condensing unit; four 13,750-sq.ft. boilers with underfeed stokers and external economizers of 7,730 sq.ft. each; and condensate storage tank, open feed-water heaters and steam-driven feed pumps. It operated originally on a plain Rankine cycle with steam at 225 lb. gage pressure and 550 deg. F. at the turbine throttle. The condensate and circulating pumps are duplex steam and electric driven, and variation of this drive affords regulation of the exhaust steam for feed-

water heating. In 1920, another 20,000-kw. generating unit was installed with boiler and auxiliary equipment, duplicating the first as to capacity and arrangement. Up to this point in operation, the heat balance of the plant was regulated by holding the temperature of the feed water to the economizers at 180 to 190 deg. F., which gave a proper balance between the water-steam cycle economy and the stack losses.

With further increase in load a third unit of 35,000-kw. capacity was added and a third group of four boilers, each with 14,643 sq.ft. of boiler surface plus 3,463 sq.ft. of integral economizer surface. The pump drive for this unit is also duplex for the condenser and steam for the boiler feed.

> In a moderate-sized plant whose development has spread over a period of years, the author traces the change in operation from the Rankine to the regenerative cycle and as a result reports a 10 per cent lower B.t.u. rate per net kilowatt-hour. An interesting feature is the passing of all make-up feed water to one boiler while all other boilers are fed condensate.

At this stage of development of load in the territory the base of the 24-hour load had begun to show considerable improvement. There was good growth of the daytime industrial load, the gap between afternoon and evening was less pronounced, the evening load period longer and the after midnight valley not so low. The effect of the load improvement on the plant heat cycle was to give greater heat-absorbing capacity of boiler feed-water above the auxiliary exhaust-steam heating capacity.

Therefore, while the plan of auxiliary drive was left the same, additional heating of feed water was obtained by changing to the regenerative cycle. Luckily, two of the turbines, the first and the third, were fitted already for stage extraction of steam at pressures and temperatures well suited to the needs of the plant cycle, from tapping points already in existence covered by blank flanges.

Air preheaters were installed with the third row of four boilers to reduce the temperature of the stack gases and allow a higher temperature of feed water to these boilers. Two low-stage extraction heaters were installed, one on each of turbines Nos. 1 and 3, and connected to the condensate line between the hotwell pump and the storage tank. At full load on the units these heaters raise the condensate temperature about 90 deg. F. above its hotwell value, which, of course, varies with the seasons, owing to variation of circulating-water temperature and condenser vacuum.

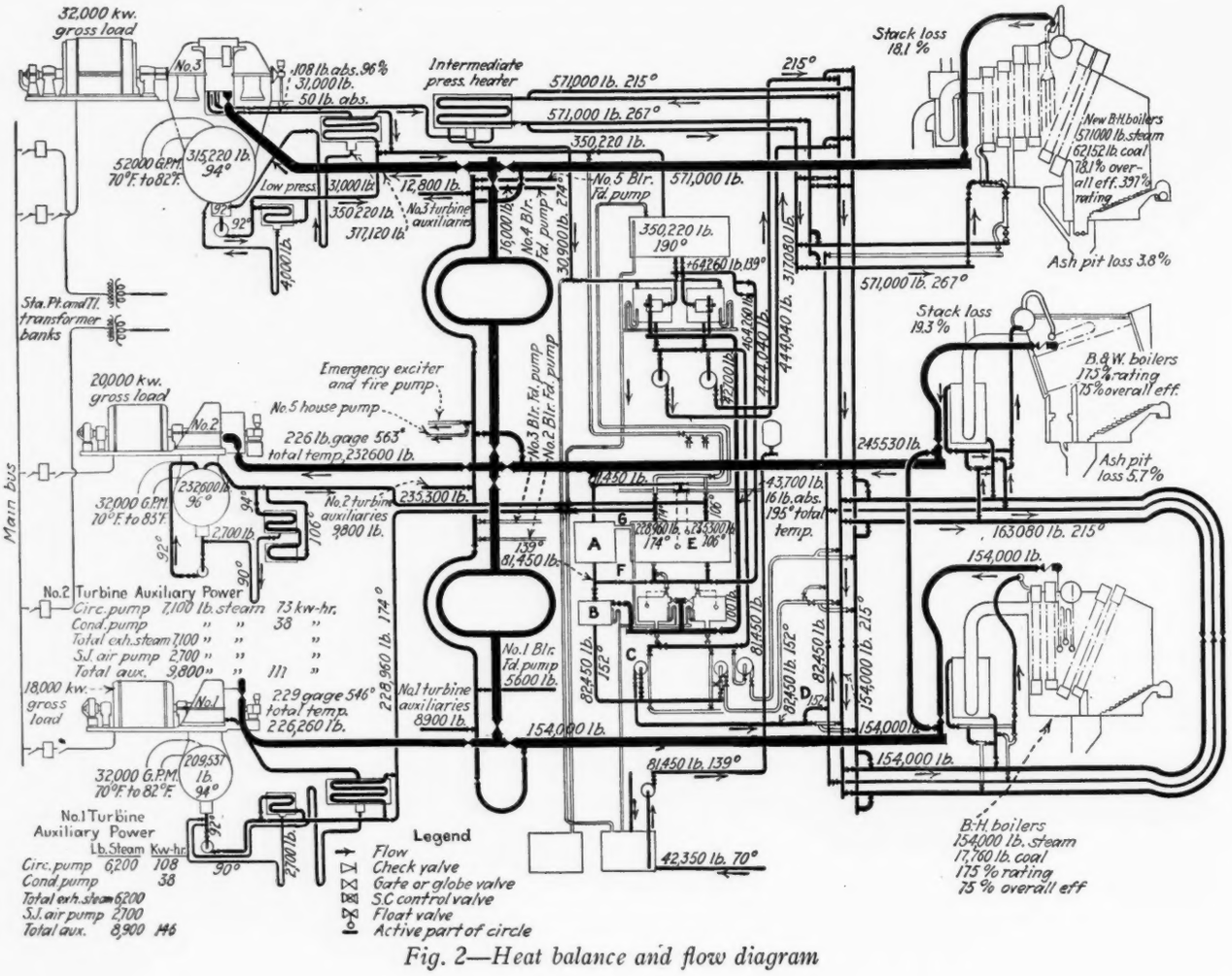


Fig. 2—Heat balance and flow diagram

One high-stage heater was installed on the third turbine, giving two-point bleeding of this machine. Inasmuch as only the new group of boilers is equipped with air preheaters and the older boilers depend on relatively cooler water to the economizers for reducing the temperature of their stack gases, the high-stage extraction heater could be used for new boiler feed water only and must be connected between the feed pump and the boilers in the new boiler feed lines. Thus it is a high-pressure heater with tubes and shell built for feed-pump pressure. It is equipped with automatic pressure differential valves for bypassing the feed water to the boilers in case of trouble of any sort in the heater. At full load on the turbine it bleeds the intermediate stage at a steam pressure of approximately 50 lb. absolute and heats the new boiler feed water to 265 to 280 deg. F., depending upon the rate of boiler operation and, hence, the rate of water circulation through the heater. This heater offers an interesting observation on the effect of velocity of circulating water on the rate of steam extraction from the turbine. With practically constant load and steam conditions on the turbine, the amount of steam extraction and heating varies with the rate of feed-water circulation through the heater.

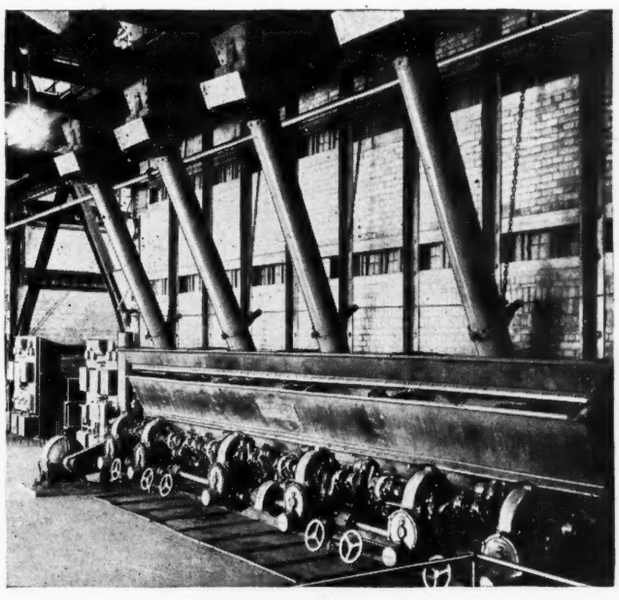


Fig. 3—Typical boiler installation

Two deaërating heaters equipped with vapor condensers were installed, replacing the old-type open heaters. These two open heaters are the only old equipment thrown out of use in the process of additions and changes to the plant. The deaërators take the condensate by gravity flow from the storage tanks above them and discharge it by gravity to the feed pumps below. The condensate in the storage tanks, being a mixture from the three turbine units, only two of which use stage heating, is at all times at a temperature well below the atmospheric vaporizing point or at a maximum of about 170 deg. F. at full load with summer season vacuum conditions. The deaërators do their work from the storage-tank temperature up to 215 to 218 deg. F. and give good results from the air removal standpoint.

After leaving the feed pump, the boiler feed water divides, a portion going to the old boiler economizers at 215 to 218 deg. F. and a portion through the high-stage heater to the air-preheater-equipped boilers at 265 to 285 deg. F.

Fig. 3 shows a sketch of the principal equipment of the plant, including a diagram of the pipe lines and valves for condensate, feed water and steam. This flow diagram gives a fair idea of the arrangement and of the heat balance. Each of the boilers represents a row of four boilers like the one shown.

A feature of the additions to the plant is the method of passing all the plant makeup water into a single boiler. This requires a separate storage tank, open heater and feed pump which feeds through the hydraulic test line to the boiler used for makeup. On the sketch these items of equipment are shown respectively at *A*, makeup tank; *B*, heater; *C*, pump, and *D*, test feed line. A float in the main condensate tank at *E* controls the valve in the makeup supply line and sends the makeup water demanded by the system into the tank *A*. Thus the flow of the makeup is controlled by the main plant condensate storage-supply level in the tank at *E*, although it sends the makeup through the isolated feed system to the one boiler. All other boilers have condensate only as feed water. The makeup boiler may be any one of the eight old boilers composing the first two rows, although one of two is generally used alternately over a period of several months. On the steam side this boiler feeds into the same header with the other boilers of the row.

The makeup boiler takes as first choice all the makeup water sent over by the float valve controlled from *E*, but it is operated along with the other boilers as a matter of course at a rating beyond the makeup rate of flow. Its additional feed water is condensate obtained from the condensate header line through a weighted check valve at *F*. And in case any emergency should throw the makeup boiler out of operation, the makeup water would rise in the tank *A* to the open connection at *G* and, flowing into the tank *E*, continue to supply the system.

Handling makeup to a single boiler is not an idea original to this plant, but the method described is our adaptation of the idea to this particular station. It is of considerable value in caring for the boilers to have all the treated water handled by the one and clean condensate used in all the others.

A B.t.u. rate per net kilowatt-hour about 10 per cent less than that previous to the changes now prevails in the plant. Part of the gain is due to each portion of the new equipment, and of course part of it comes from more favorable load conditions, although this point would not represent a gain necessarily, unless properly handled.

Pulverized Coal Facts

Users of pulverized-coal equipment are always interested in learning, for purposes of comparison, the experiences of other plants as to maintenance, sustained fineness of pulverization and power requirements. Read Guy B. Randall's article next week. He gives these facts and a lot more from personal experience with a remodeled boiler setting of unusual design and unit mills.

Taking Samples of Pulverized Coal

By J. S. Evans
Commander, U. S. Navy

IT HAS been found that the feasibility of burning pulverized coal in the small water-cooled furnaces of a Scotch marine boiler depends on having a suitable burner that will give the necessary turbulence and intermixing of the coal and air necessary for combustion, and on the fineness of the coal delivered to the burner. Smaller particles of coal make for a shorter flame than do larger particles, even though the air supply is regulated as carefully as possible.

Therefore, during all tests of burning pulverized coal at the Philadelphia Fuel Oil Testing Plant of the Navy, samples of the product from the pulverizer are taken at frequent intervals in order to determine how the fineness of the product was influenced by the following operating conditions: (1) Varying speeds of the mill with any given capacity output; (2) varying capacity outputs at any given speed; (3) varying velocities and quantities of air through the mill; (4) varying kinds of coal, and (5) the wear of the pulverizing media or parts. The information obtained from the sieving tests of these samples is necessary in order to ascertain the best method of operation to obtain as fine a grind as possible, so that comparisons of various pulverizers may be made. The tests also show when the pulverizing media or parts are so worn as to require addition or replacement or maintenance of the parts.

Design of the Test Apparatus

In one of the installations made at the testing plant, the pulverized coal was drawn from the mill by the primary air fan and discharged through a duct to the

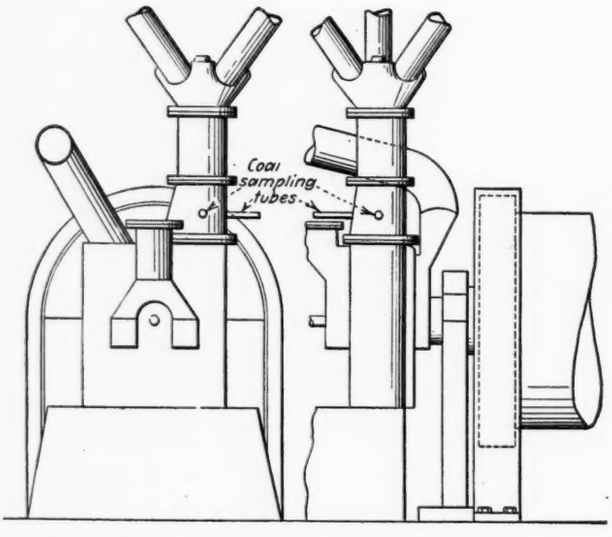
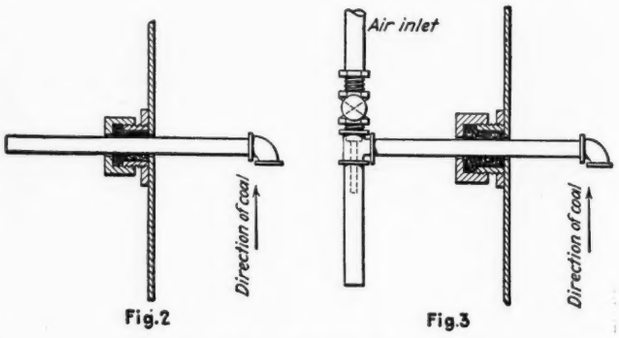


Fig. 1—Location of sampling tubes in the pulverizer

distributor. This duct was of rectangular cross-section at the fan outlet, changing to circular as it neared the distributor. On account of local interferences it was practicable to fit the sampling tubes only into that portion of the duct of rectangular cross-section, and this portion was fitted with two tubes at right angles to each other. Each tube consisted of 1-in. I. D. brass pipe, fitted on its inner end with an elbow pointing counter to the direction of the flow of air and coal in the duct. Its outer end had suitable equipment for attaching the bag from an ordinary vacuum cleaner. Each sampling tube was arranged to slide through a gland-packed stuffing box in the duct wall, and was marked along its length into equal divisions, each division representing one-tenth of its total travel in the duct. Sampling tubes were closed at their outer ends when not in use, by rubber stoppers.

Taking Samples

When a sample was to be taken, the stopper was removed from the tube, the bag attached and the tube moved so as to traverse the duct, the tube being held



Figs. 2 and 3—Details of the tubes

stationary for one minute at each marked point on its length. The bag was then shifted to the other tube and the duct similarly traversed. The entire time of taking a complete sample was twenty minutes. This sample was then quartered in the usual manner to obtain the amount necessary for the sieving tests, and was placed in an air-tight can, to be held until the tests could be made in the laboratory.

The locations of the sampling tubes are shown in Fig. 1, and Figs. 2 and 3 show the sampling tube in detail.

With the present installation in the plant, the pulverized coal is drawn from the mill and through a classifier exterior to the mill, by a fan which is some distance from the mill outlet, and then delivered by this fan to the duct leading to the distributor. It was desired to take samples both before and after the classifier. Samples after the classifier—that is, from the discharge duct between the fan and the distributor—were taken in the manner described, but for taking the samples before the classifier—that is, from the fan suction duct between the mill outlet and the classifier—a modification of the sampling tubes was necessary. This modified tube is shown in Fig. 3, the modification consisting of fitting the sampling tube with a connection to an air line, thus permitting a sample to be drawn from the duct. Otherwise the entire sampling arrangement was as described in an earlier paragraph.

The method of taking samples herein described might reasonably be criticized as not giving a correct sample, in that equal areas of the ducts were not represented in each of the one-minute periods; but it does give what is believed to be a representative sample. It is not a laboratory method of sampling, where extreme accuracy is necessary. It is, however, a method that can be cheaply and easily installed, and irrespective of whether the samples are truly representative, it will give a true comparison of the various conditions of operation, which is what is desired.

Right Out of the Plant

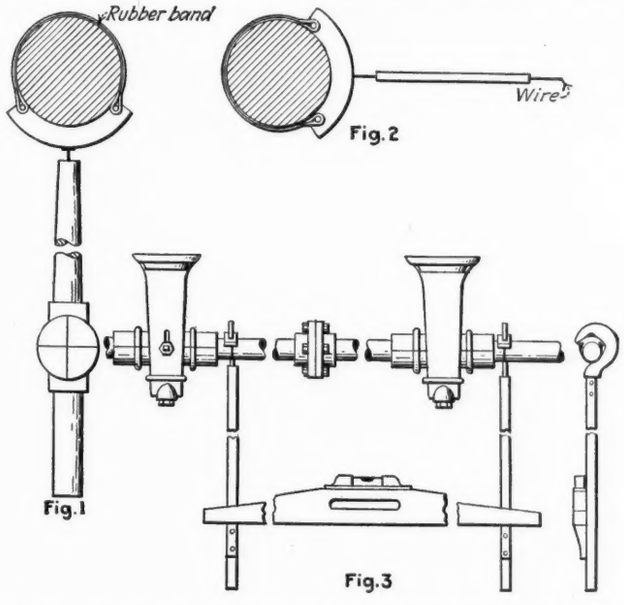
BOILED-DOWN EXPERIENCE PASSED ALONG TO THOSE WHO MUST SAVE MONEY, IMPROVE THE PRODUCT AND KEEP THE PLANT RUNNING

Simplifying the Aligning and Leveling of Shafting

LINESHAFTING generally decreases in diameter from the point from which it is driven to its other end, or ends, according to whether it is driven from one end or from some intermediate point. When leveling or aligning such shafting, the difference in diameters involves a certain amount of adding or subtracting, and it is easy to make an error.

One line of shafting that it was my duty to level and align from time to time varied in diameter from $4\frac{15}{16}$ to $1\frac{9}{16}$ in., the intermediate diameters being $4\frac{7}{16}$, $3\frac{15}{16}$, $3\frac{5}{16}$ and $2\frac{7}{16}$ in. I got tired of figuring and decided to make a little tool that would simplify the job and make the shafting all of the same diameter as far as the work of aligning it went.

This was done by casting a slug of babbitt large enough to turn up in the lathe to $4\frac{15}{16}$ in. diameter. This done, a hole was bored through it lengthwise and rings $\frac{3}{8}$ in. thick were parted off, one of each of the following inside



Figs. 1 to 3—Segments to fit the various sizes of shafting obviate a lot of figuring when leveling and aligning

diameters: $4\frac{7}{16}$, $3\frac{15}{16}$, $3\frac{5}{16}$, $2\frac{7}{16}$ and $1\frac{9}{16}$ in. The rings were cut into three segments, each segment having stamped on one of its sides its inside diameter, the outside diameter of all the segments being $4\frac{15}{16}$ in.

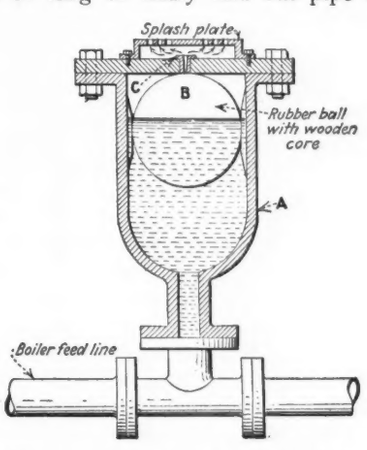
In a hole in each end of each segment was driven a steel pin $\frac{1}{8}$ in. diameter by 1 in. long, for attaching a rubber band made from an old inner tube. A segment of the proper inside diameter was clipped on the shaft close to each bearing. For leveling they were placed as shown in Fig. 1, and for aligning as in Fig. 2, the segments being kept tight to the shaft by the rubber bands. If I make another set, I shall make them of aluminum.

Where an engineer's level is not available, the segments can be placed on top of the shaft, and the usual straightedge and a machinist's level used, as in Fig. 3, but whenever possible, both for speed and accuracy the engineer's level should be used. E. J. JORDAN.

Long Beach, Calif.

Removing Air from Boiler Feed Line

CONSIDERABLE trouble is often experienced in power plants owing to air being released from the feed water and collecting at some high point in the main. In the case of long or badly laid out pipe line an air



Air separator connected to feed line

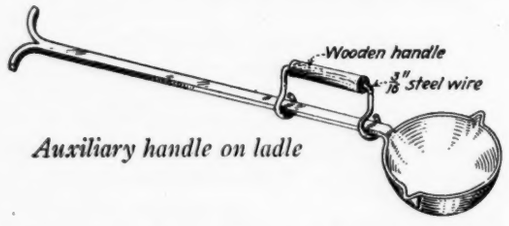
lock may result, causing a complete stoppage of water until the air is removed. In the power station of the London Hydraulic Supply Company, Wapping, London, there was considerable trouble due to the collecting of air in one of the boiler-feed lines. It was overcome by the device shown in the sketch. The water was supplied under a pressure of 160 lb. and the boilers were in continuous operation.

The device consists of a cast-iron body *A* and a floating ball *B*, the ball being an easy fit in the guides on the body. The ball has a wooden core $5\frac{1}{2}$ in. in diameter covered with rubber. Over the body is fixed a cast-iron cover in which is screwed a small nipple *C*. The inner end of the nipple forms a seat for the ball, and the other end is open to the atmosphere. A perforated splash plate is fitted on the cover to prevent any water that may be blown out being splashed around the plant. The separator is fitted to the pipe line at the highest point in a vertical position. When free from air, the floating ball rises with the water and seals the small orifice in the nipple. When air is released from the water, it collects under the ball and displaces the water supporting it. When sufficient air has accumulated, the ball drops away from the seat and permits the air to escape. When the air has been discharged, the ball rises again and seals the orifice. W. E. WARNER.

Brentford, England.

Sliding Handle for Babbitt Ladle

A CONVENIENT auxiliary handle that can be fitted to any babbitt ladle is made from a short length of wooden bar such as a piece of broom handle, drilled through for a piece of heavy wire or ¼-in. round rod which is bent around the ladle handle as shown, so that it is loose enough to slide up and down readily. With



Auxiliary handle on ladle

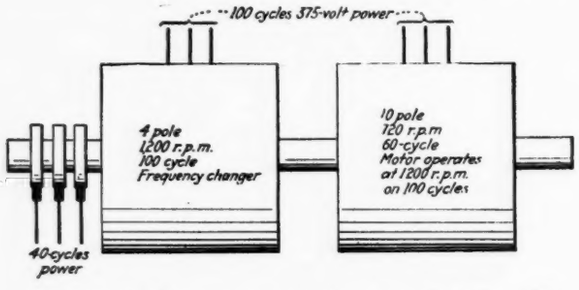
this attachment the user always has a cool handle near the hot metal. Of course it is slid back when the babbitt is being melted. Such a handle, being above the surface of the metal, prevents splashing on the operator's hand as the ladle is carried to the job. H. MOORE.

Hamilton, Ont., Canada.

An Unusual Frequency-Changer Application

WOOD-WORKING establishments, like many others, have their own particular power requirements. High-speed cutters are the rule rather than the exception. This condition led one plant, which generated its own power, to install a 100-cycle 375-volt three-phase system for a general-purpose supply.

Among the production machines in the plant was a motorized molder with the heads operating at 6,000 r.p.m. However, later developments proved 3,600 r.p.m. was necessary. Ordinarily, the addition of a 60-cycle generator would have taken care of the situation, but in



Frequency-changer connections to produce 40-cycle current from a 100-cycle source

this instance expensive mechanical modifications would have been required.

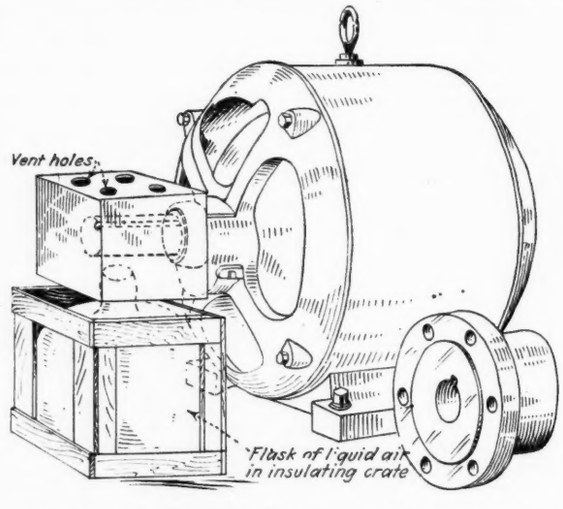
A standard four-pole frequency changer, designed normally to operate at 1,200 r.p.m. and provide 100-cycle output when excited at 60 cycles, was selected and mounted on a common base with its direct-connected driving motor. As normally used, 40 of the 100-cycle output is due to rotation and 60 to excitation. Applying 100-cycle excitation with the same speed and direction of rotation would give 140-cycle output, but reversing the direction of rotation or its equivalent (interchanging a pair of the excitation leads) would cause the excitation frequency to subtract instead of add. In this manner was secured 100 minus 40, or 60-cycle output. In order to get 1,200 r.p.m. with 100 cycles only available, a standard 10-pole 60-cycle 220-volt 720-r.p.m. motor was applied. The driving motor functions as a regenerative brake and holds the frequency changer at 1,200 r.p.m. instead of driving it. Advantage was taken of the fact that the motor was to operate above its listed speed because of the higher frequency and, further, that the motor losses absorb some power which, under the circumstances, is advantageous in keeping down the size.

It may be noted that the stators of both the frequency changer and motor are operating at normal flux density, since both the voltage and frequency have been raised in the same proportion above the 60-cycle values. The bearings and balance of the motor were checked and found to be satisfactory. When used as described, the 60-cycle capacity of the frequency changer is not so great as when it is used to raise the output frequency above that of the supply. F. H. PENNY,

Schenectady, N. Y. General Electric Company.

Installing a Coupling by the Cold-Shrink-Fit Method

SOME time ago an ingenious mechanical friend had occasion to shrink a coupling half on the shaft of a motor that was located in a tight place close to a lot of delicate electrical equipment. He was afraid to use



Evaporation of the liquid air lowered the temperature of the shaft, permitting coupling to be slipped on

a kerosene torch, and no other means of heating was available. Also he had no easy means for handling a hot coupling half.

After some thought he hit upon the idea that a shrink fit can be made by cooling the shaft just as well as by heating the coupling. So he went to a near-by university physics laboratory and bought a large flask of liquid air. He placed this under a box surrounding the end of the shaft, pulled out the stopper and waited until the air had evaporated. Removing the wooden box from the shaft, he found that the coupling half would go on easily, and that is all there was to it.

I suppose that it would not do to hit the shaft while it is so extremely cold, for steel becomes brittle at very low temperature, but once it warms up again, there seems to be no permanent change in the metal.

This ought to be a good way to make shrink fits—no heat, no fire, no smoke. JAMES A. HARRIS.

New York City.

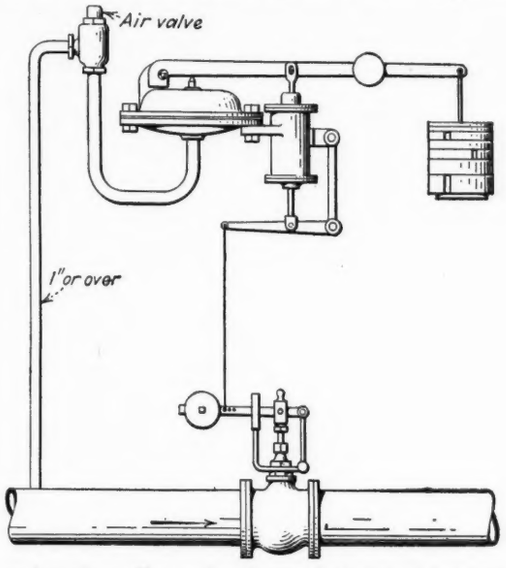
As the Other Fellow Sees It

WHERE THE MAN WHO AGREES OR DISAGREES WITH AUTHORS OR EDITORS HAS A CHANCE TO SPEAK UP

Proper Line Connection for Pilot Valve

SOME time ago I noticed an article on a reducing valve which failed to function until a faulty pilot-valve connection was corrected.

When the source of supply for the pilot valve is taken from a point above the motor or mechanism which operates the valve, no trouble should ever be experienced,



Connection for pilot valve located above the steam line

but when it is taken from below, the line has to be correct.

In my own case I always connect the valve as shown in the illustration and have never had a failure.

New York City. C. W. PETERS.

* * * *

Imagine the Savings

I SHOULD like to add a few comments to what has already been said on the subject of "Imagine the Savings."

Suppose the designing engineer would really take advantage of the opportunities he has within his own organization for expert advice. If, when a new design is in the development stage, and before it is detailed for production, he would frankly invite the shop foreman, power foreman, etc., to inspect the layout, and give him any suggestions they might have to improve the details for greater endurance, cheaper manufacturing costs and accessibility for servicing, what a real saving that would be! Once detailed and in production, each change suggested is a challenge to professional pride and, consequently, is met with a certain degree of psychological opposition.

Think what it would mean if a running record of parts and raw materials in stores were made easily accessible to the draftsman. Try to picture how many new details, designed as a matter of routine by the individual detailer at present, would never be even thought of if the information on stores parts were readily available. Raw material now lying indefinitely in storehouses, to be ultimately sold as scrap, might readily be used in new designs if the draftsman only had the information conveniently at hand.

Imagine the savings on special shop equipment if the individual authorizing the special design were made to sign a statement that he had fully investigated the possibility of commercial equipment and that there was none suitable available; or, in the other instance, if the statement said that commercial equipment available at a quoted price was not feasible because of the following listed facts. The increased use of commercial equipment in lieu of the many special installations so prevalent today would be amazing; the savings would be obvious.

Suppose, when a major executive has an idea for a new design or improvement, the draftsman assigned to the job could feel free to present an analysis and sketches for criticism and approval rather than a completely detailed design, which at present the major executive's dignity seems to demand.

Imagine the benefits to be gained if we could change our mental attitude so that the allowing and authorizing of changes on drawings suggested by the shop would be an indication of strength rather than weakness on the part of the engineering department. At present, no matter what their origin, changed drawings, by their increasing volume, reflect unfavorably on the drafting room. Under such conditions we would get the maximum of production design, with its resultant shop economies.

JOHN F. HARDECKER, Chief Draftsman,
Philadelphia, Pa. U. S. Navy Yard.

* * * *

Cutting Out Coils in the Ice Tank

IN THE issue of May 29, I made a statement that on account of the coils in an ice freezing tank being divided into four groups, advantage may be taken of this arrangement to use only one of the groups in the winter when making a small quantity of ice per day, and by the aid of agitator circulation have it perform the office of a bunker coil and thus refrigerate the whole of the brine in the tank. In this way a small pump-out machine could be used for the work, whereas if all the coils were kept in operation, the volume of vapor coming from the tank would be too great for the pump-out machine to handle.

A. E. Wion in *Power* of July 17, observed that as the heat abstracted in each case would necessarily be the same, the amount of vapor would be the same. This is incorrect and could be correct only in one instance, and that is when the temperature and pressure were exactly the same in both cases. In a practical case a 6x6-in. twin-cylinder machine gave much different results.

To show clearly why Mr. Wion's assertion does not hold good and to aid those who may wish to calculate to see why, let us figure the problem out and, in doing so, refrain from using data brought out by the test.

The tank in question is one of four used to make 200 tons of ice daily in summer. It contains five hundred and forty 300-lb. cans and a little over 12,000 lin.ft. of 1¼-in. pipe. Cans are filled directly from the city mains with water at 40 deg. F. The condenser pressure is 100 lb. gage. It is required to make ten tons of ice daily in winter. The insulation being very good and the weather being cold, it is sufficient to allow 5 per cent heat leak.

We may first calculate the heat to be taken up. In doing so it is accurate enough to take the specific heat of water as 1 B.t.u. and the latent heat of ice as 144 B.t.u. Allowing 5 per cent leakage, the heat to be taken up is 3,192,000 B.t.u. in 24 hours. There are two 3-hp. agitators in the tank; the heat equivalent of the work they do in circulating the brine is added as heat to the brine, and as one horsepower is equivalent to 42.4 B.t.u. per min., in 24 hours they will have given 122,112 B.t.u. to the brine. This, added to 3,192,000 B.t.u., makes a total of 3,314,112 B.t.u. that the compressor has to remove in 24 hours, which amounts to 138,088 B.t.u. per hour, or 2,301 B.t.u. per minute.

Next we may compute the pipe surface; 2.301 lin.ft. of 1¼-in. pipe has one square foot of outside surface, so the tank contains 5,217 sq.ft. of pipe surface, one section containing 1,304 sq.ft. This particular tank has a coefficient of heat transfer of 22 B.t.u. per square foot per hour per degree temperature difference when the plant is making 200 tons of ice daily. But this coefficient could not be applied to the general run of tanks, 15 B.t.u. being the average figure. We will use 22 B.t.u. in this calculation, so that we may check our results with the actual performance.

Now 138,088 B.t.u. per hour will have to pass through 5,217 sq.ft. of pipe in one case and through 1,304 sq.ft. when using one section. In the latter case it amounts to 105 B.t.u. per sq.ft., so there will have to be a temperature difference of 105 ÷ 22 = 5— deg. to allow these B.t.u. to pass in a given time to make ten tons of ice daily.

When we pass 138,088 B.t.u. per hour through 5,217 sq.ft. of pipe, we find that it amounts to 26 B.t.u. per sq.ft., which calls for a little over a degree of temperature difference between the brine and the ammonia. Now the freezing time of the ice is a factor that has a mighty influence. If we are to maintain a one-degree temperature difference, the freezing time is going to be much longer. If we maintain a greater temperature difference, we are going to pass more heat and make a greater quantity of ice or we are going to carry the coils nearly empty, which means that the superheating will be beyond control. We will now have to compute the freezing time, so that we may get something tangible to work with, such as the pounds of liquid ammonia needed and the suction pressure. From these we can figure how much liquid and how much vapor is in the coils and check up on our calculations. Sixty-seven 300-lb. cans will have to be withdrawn from the tank in 24 hours to make ten tons daily. This is equivalent to 138,088 B.t.u. per hour. Now to freeze down the whole tank of 540 cans will take 540 ÷ 67 = 8.06 days, or 193 hours of freezing time.

The generally accepted formula for freezing time is $T = \frac{C\ (\text{thickness})}{32 - \text{temperature of brine}}$; where T is the freezing time in hours and C a constant, which is generally 7 for most plants, but for this plant happens to be 6.44 and the thickness is taken as 11 in.

The object now is to find out what brine temperature is necessary, so by using this formula transposed, we find that the brine temperature should be 32 — 4.4 = 27.6 deg. F. We have seen that to make ten tons of ice with one section of the ice-tank coil, we must maintain a temperature difference of 5 deg., so it is obvious that the temperature of the evaporating ammonia within the coil must be 5 deg. below 27.6 deg., or approximately 23 deg. F. This gives us a suction pressure of 36.8 lb. gage when using one section of the coil.

We may say for convenience that, using the whole coil, we must maintain a two-deg. temperature difference. This gives us a suction temperature of 26 deg. and a gage pressure of 40.2 pounds.

The condenser pressure has been stated as 100 lb. gage. Now the heat that one pound of liquid ammonia will take up after deducting the liquid heat above 26 deg. at 40.2 lb. pressure, or 113.2 — 71.3 = 41.9 B.t.u., is 548.1 B.t.u. — 41.9 = 506.2 B.t.u. To make ten tons of ice at this pressure, 4.54 lb. of liquid ammonia will have to be circulated per minute. The vapor generated from this liquid will amount to 23.73 cu.ft. per min. Using one section of the coil, the heat picked up by a pound of liquid at a pressure of 36.8 lb. after deducting the heat in the liquid above the evaporating temperature, 23 deg., is 505.4 B.t.u. To make ten tons of ice, 4.55 lb. of liquid will have to be circulated per minute. The vapor generated from this liquid will be 5.55 cu.ft. × 4.55 = 25.27 cu.ft. per min., as against 23.73 cu.ft. per min. using the entire coil.

This does not look like the amount of vapor being the same in both cases, for in 24 hours the compressor has to pump 34,171 cu.ft. of vapor to make ten tons of ice in one case, while in the other case it will have to pump 36,388 cu.ft., a difference of 2,217 cu.ft. in favor of the whole coil.

These figures contradict the statement that the amount of vapor coming from the entire coil would be too great for the compressor to handle.

Let us calculate how much liquor should be in the entire coil when operating under these conditions.

As 96¼ lin.ft. of 1¼-in. pipe contains 1 cu.ft. of capacity, there are 125 cu.ft. in the entire coil. The vapor generated per second will be 0.4 cu.ft. The other 124.6 cu.ft. must contain liquid, for the compressor will have to take 0.4 cu.ft. away per second or the pressure in the coil will rise. A vapor cannot be superheated in contact with its liquid, for if more heat is applied more liquid will evaporate. The vapor must be removed from contact with its liquid to superheat. If the coil does not contain 124.6 cu.ft. of liquid at any particular instant, the coil is only partly full and superheating is taking place.

A pound of liquid ammonia at the temperature of 26 deg. F. and pressure of 40.2 lb. at which the coil is working, will occupy a space of 0.024 cu.ft. or 40 lb. to the cubic foot, so the coil should contain 124.6 × 40 = 4,984 lb. of liquid ammonia, or fifty 100-lb. drums.

The cubical content of one section is obviously one-fourth of the entire coil, or 31 cu.ft., and the vapor volume per second is 0.42 cu.ft. The volume of liquid ammonia at 23 deg. F. and 36.8 lb. gage when using one section is practically the same, so 1,240 lb. of liquid ammonia would be needed, a little over twelve 100-lb. drums.

F. P. MacNeil.

New York City.

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

Air Compressors for Auxiliary Power in Starting Diesel Engines

A COMPLETE line of Diesel and high-pressure auxiliary air compressors, designed for providing starting air, emergency injection air and charging air bottles has recently been brought out by the Rix Company, Inc., 400-404 Fourth St., San Francisco, Calif.

Three of the models, specified as DE, DF and DF2, are self-contained gasoline engine-driven units and are suitable for operating pressures from 250 to 1,500 lb. The DE single-stage unit is illustrated in Figs. 1 and 2, and

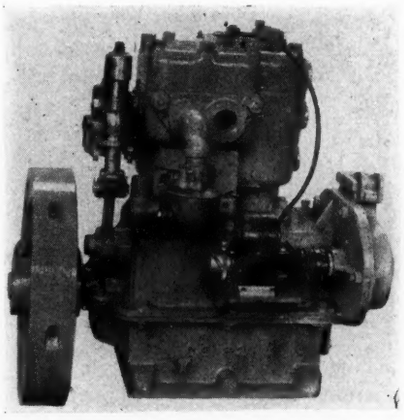


Fig. 1—Model DE gasoline-engine-driven auxiliary air compressor

the two-stage unit suitable for pressures up to 1,500 lb. is illustrated in Figs. 3 and 4. The construction of the DE and DF single-stage models is practically identical with the exception that the DF models are larger in capacity and the motor and compressor cylinders are cast separately instead of on the same block.

The units are entirely inclosed and provided with splash lubrication. The cylinders and heads are completely surrounded by cooling water, and the flow is directed to eliminate dead pockets and hot spots. Both inlets and the discharge valves are of the Rix plate type, which are concentric steel plates of uniform section and light weight. Closing of the valves is accelerated by conical self-cleaning springs.

The crankcase is fitted with a large inspection door and drop bottom, giving ready access to the main and

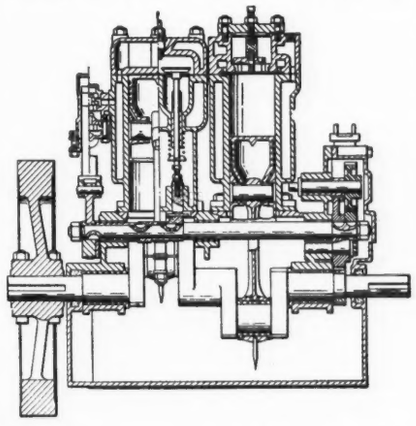


Fig. 2—Cross-section through engine and compressor

connecting-rod bearings. The automobile type of piston is used. Six snap rings are provided on the air

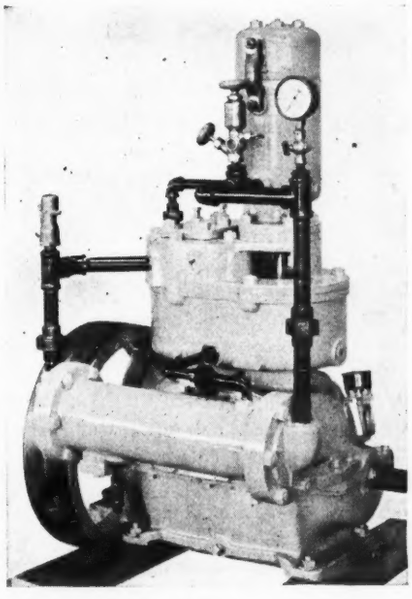


Fig. 3—Type XH two-stage compressor for 1,500 lb.

piston, with the lower ring arranged to eliminate oil pumping. The engine piston carries five rings. The piston-pin bushings are special bronze pressed into place and reamed to fit. The main bearings are nickel, babbitted in place and bored to fit. Crankpin bearings are bronze-backed babbitt. The crankshaft has an enlarged section between the throws, giving increased rigidity. The cooling-water pump is all bronze, plunger type, driven by an eccentric from the camshaft. On the two-stage machine the air from the low-pressure cylinder is passed through an intercooler, connected in the water-cooling system.

The two-stage compressor illustrated in Figs. 3 and 4, is known as

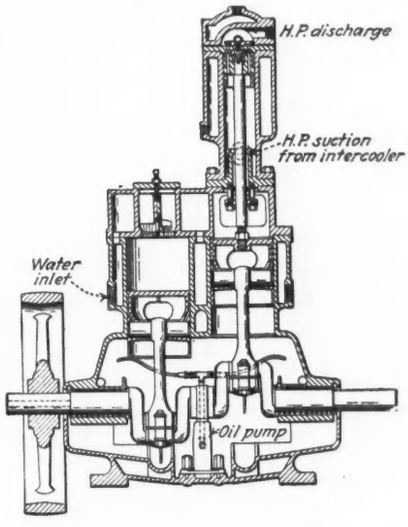


Fig. 4—Cross section of XH type

the XH type and is especially adapted to direct connection to engine or motors as they are designed for speeds varying from 630 to 875 r.p.m. according to the size of the compressor.

In the three models previously mentioned, the DE is a single-stage machine with a piston displacement of 12 cu.ft. at 300 lb. pressure. Corresponding figures for the single-stage model DF are 21 cu.ft. displacement, 300 lb., and the DF two-stage model 10 cu.ft. at 1,500 lb. In the XH type the diameters of the low-pressure cylinders range from $4\frac{1}{2}$ to 9 in., the high-pressure cylinders from $1\frac{5}{8}$ to 4, the piston displacement from 30 to 130 cu.ft., and the pressures from 500 to 1,500 pounds.

"Replate" Globe and "Perfection" Self-Grinding Valves

A NEW line of valves known as the "Replate," made in globe, angle and Y bodies and designed for both high- and low-pressure service, has been brought out recently by the Central Valve Manufacturing Company, 435 North Michigan Ave., Chicago.

In this valve, shown in section in Fig. 1, the head of the stem is capped with a removable cold-rolled nickel plate, formed to give a ball joint effect, and fully supported by the end of the stem. This head plate works against a Monel-metal removable seat. Being somewhat softer, the nickel head plate takes most of the wear and has been designed so that it can be replaced readily without removing the valve from the line.

The end of the stem has been designed to seat in the open position to permit repacking the valve under pressure in the wide-open as well as the closed position. A large air space in the bonnet prevents rapid transmission of heat from the body to the handle, and the short stem and bonnet reduce to a minimum the space required for installation.

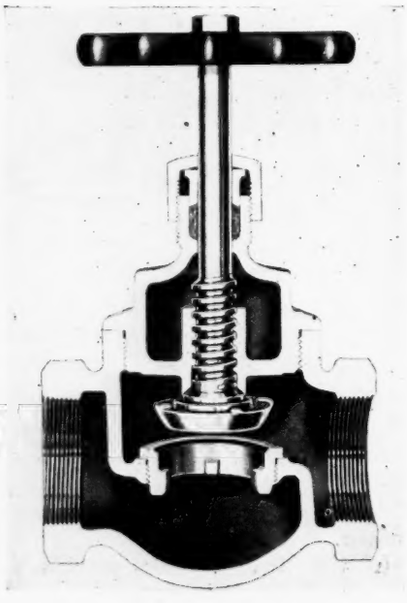


Fig. 1—The "Replate" globe valve in section

Fig. 2 illustrates a line of improved "Perfection" self-grinding valves, also manufactured by this company. The important feature of this valve is the use of a short spiral spring *A* and a spring block *B* threaded to the valve stem, which forces the valve to its seat. This feature causes the disk to be revolved on the seat when the valve is being closed, and this tends to remove any dirt or scale from the seat. As the stem comes to a seat in the body, the threaded section of the stem being engaged with the threads in the spring block *B*, the latter moves upward on the stem compressing spring *A*. The pressure of this spring against the block holds the valve to its seat. Further rotation of the stem brings the spring block solidly against its upper stop in the bonnet and the valve to a firm seat. Meanwhile the stem has been revolving on its seat and has ground itself in. Where additional grinding is necessary, a short movement of the handwheel back and forth in the closed position is sufficient.

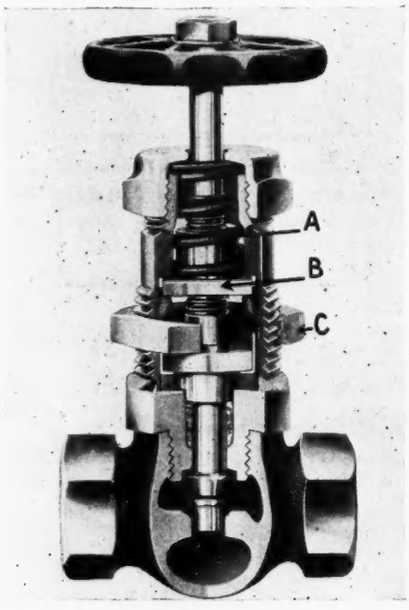


Fig. 2—Section of the "Perfection" self-grinding globe valve

A shoulder on the head of the stem makes a tight joint on the inside face of the bonnet when the valve is in a wide open position, allowing for repacking under pressure. As the stem threads, spring and spring block are located outside the bonnet above the packing, they can be lubricated easily and are not subjected to the effects of heat and corrosion. To control the grinding pressure on the seat according to the varying operating pressures and hardness of the impurities encountered, the spring-retaining cap at the top of the bonnet may be adjusted up or down within a definite range. The packing gland is tightened by screwing down on the nut *C*. These valves are intended for working pressures to 300 lb. gage and temperatures to 550 deg. F. Gage cocks designed on the same principle are also available.

Equipment for Changing Transformer Taps Under Load

THE Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has brought out the transformer tap-changing equipment illustrated.

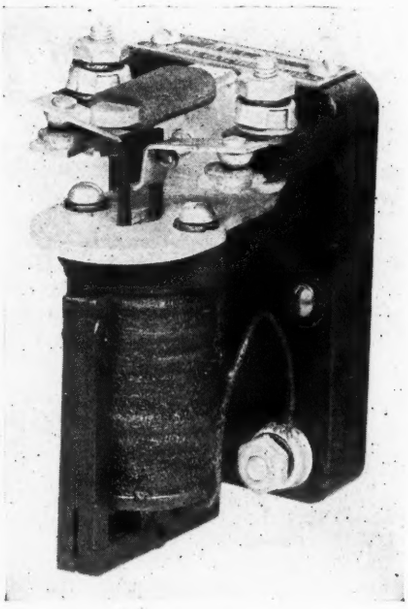
The unit is arranged for mounting directly on the transformer tank. The housing is divided into two oil-filled compartments by means of a baseplate on which the tap-changing switch bushings, camshaft and toggle mechanism are mounted. The upper compartment opens directly into the transformer, facilitating connection of transformer leads and completely immersing them in oil.

Type UB tap-changing equipment for mounting on transformer tank

The lower parts of the bushings extend into the lower compartment and carry the stationary contact feet. To withstand the frequent service required, condenser bushings with wedge-shaped contacts are used.

The moving contact is operated from a toggle and cam operating mechanism. Proper sequence of operation is assured by forced opening and closing of the contacts. By using small-diameter cams, the main operating camshaft is machined from one piece of steel.

The equipment is designed for either hand or remote control operation. Only one switch operation is needed per tap change, and every position is an operating position. Oilless graphite bearings are used throughout.



Front view of undervoltage relay

New Relay Warns When Power Fails

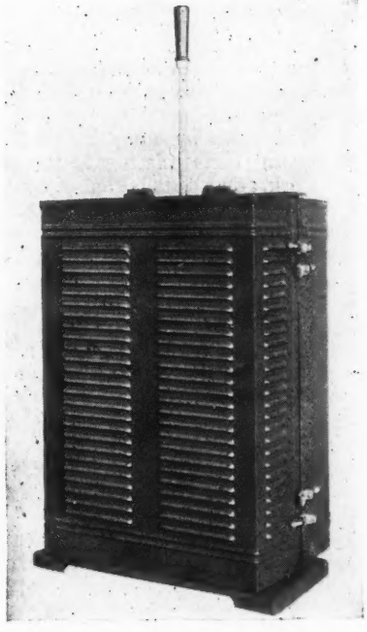
A NEW signal relay, shown in the figure, announced by the General Electric Company, is designed for application where a small, inexpensive device is needed to actuate a warning signal when the power fails or the voltage drops on an important circuit.

In operation the coil circuit of the relay is connected across the two legs of the power supply which it is desired to watch. When the coil is thus energized, the relay contacts are held in an open position. By connecting a circuit through the contacts to a bell, horn, light or other signaling device, warning will be given when the power fails or voltage drops, as in that event the coil will be de-energized, the contacts will close and the circuit to the warning signal will be completed. The relay can be used on either direct or alternating current.

The relay is of the solenoid type, having a laminated armature of three sections, the central leg of which is fastened to a bakelite operating arm which raises and lowers the contact tips. The entire device is mounted on a molded compound base, only $1\frac{7}{8}$ in. wide and $2\frac{1}{2}$ in. high, and is packed in a small cardboard carton together with a small, enameled-tube resistor the rating of which varies according to the voltage and frequency of the application. The relay can also be supplied for panel mounting.

When used as a voltage-drop warning device, adjustment to the proper operating voltages is made by means of an adjustable brass screw protruding into the air gap over the outside leg of the armature. Thus a fine adjustment of pick-up and drop-out may be obtained. In actual tests the relay was made to drop out at 106 volts, after picking up at 112 volts, or at 95 per cent of the pick-up voltage, and held this ratio over a considerable range.

A typical application of the relay is on storage-battery charging outfits. When the battery falls below the critical voltage, the relay places it on charge or increases the charging rate, and disconnects it when the voltage has come back to its full value.



Rear view of controller with both covers in place

Dinky Controller Has Nickel Alloy Resistors

THE Electric Controller and Manufacturing Company, Cleveland, Ohio, announces the new dinky-type controller shown in the accompanying illustration.

In this controller ebony asbestos is used instead of slate for mounting the contacts. Ventilation of the contacts is obtained by supporting them $\frac{9}{16}$ in. from the dial's face. The contact supporting lugs are attached to the front of the dial and are removable from the front. These lugs have a single square-head setscrew to clamp the lead wire tightly.

The controller is supported in a welded steel frame, and the main operating arm is mounted on ball bearings. The bearing spider casting supports the dial as well as the arm and quadrant bearings, thus insuring correct alignment and even contact pressure. Nickel-alloy resistors, guaranteed against breakage during shipment and for one year in service, are used.

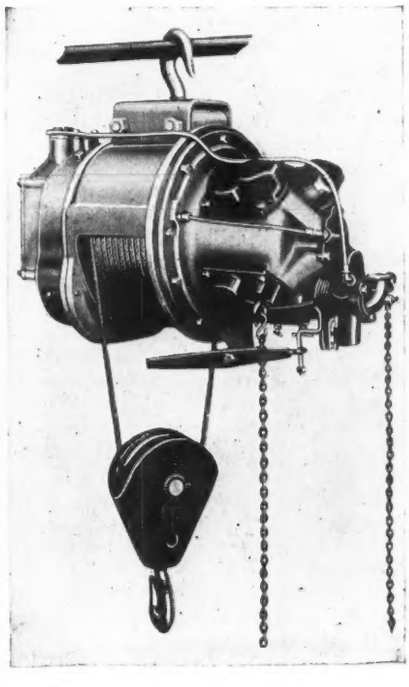
Improved Pneumatic Air Hoist

THE Chicago Pneumatic Tool Company, 6 East 44th Street, New York, has brought out a line of improved air hoists embodying several distinctive features. The three sizes now available have a capacity of 2,000, 3,000 and 4,000 lb. respectively, and have an inclosed-type load block and simple control.

The motor is four cylinder, single-acting, and practically vibrationless. The hoist forms a compact unit requiring a minimum of headroom. A balance-type control valve gives smooth and positive control of the hoist. The lifting speed has been considerably increased over former models. The one-ton size will lift 2,000 lb. at a speed of 40 feet per minute.

Other features include case-hardened steel reduction gears, large ball bearings on the crankshaft, brake drums lined with asbestoes brake lining, and pressure lubrication.

Four-cylinder air hoist built in 1, $1\frac{1}{2}$, and 2 tons capacity



Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

New York Plans for Large Attendance at Seventeenth Annual Safety Congress

Among the many sections of the congress will be included sessions on engineering, public utilities and refrigeration

FIVE hotels will be required to house the 110 meetings, 325 speakers and 6,000 persons expected at the Seventeenth Annual Safety Congress, which will be held at New York City, Oct. 1-5 inclusive, when the question of how to check accidents on the streets and highways, in other public places, at home and throughout industry will be considered.

Accident preventionists from coast to coast will relate their experiences in successfully conserving lives and limbs and property. Health authorities will dwell on the subject of looking after the physical welfare of industrial employees. Fire prevention specialists will outline methods of curbing the terrible toll taken by flames. A public speaking instructor will teach the safety crusaders how to deliver addresses in the modern manner. Public officials, whose job it is to safeguard people on the streets and highways, will give demonstrations of their methods. The latest mechanical safeguards and safety devices will be on exhibit. There will be breakfast meetings, luncheons, dinner sessions, evening gatherings, a mass meeting of members, a session for women, executive conferences and numerous entertainments.

Meetings will be held in the Hotels Pennsylvania, Waldorf-Astoria, McAlpin, Martinique and Commodore. There will be no charge for admission and nonmembers of the National Safety Council also will be welcome to attend the various sessions.

The members of the American Society of Safety Engineers, who comprise the Engineering Section of the National Safety Council, will hold its first gathering on Tuesday afternoon, Oct. 2, in the Pennsylvania Hotel, where all meetings of that group will take place. Progress reports on "Annealing Chains" and "Wire Rope Attachments and Connections" will be presented and discussed.

A luncheon will be held on Wednesday, Oct. 3, at which Chairman R. McA. Keown will make his report for the year. Election of officers will follow.

On Thursday afternoon, Oct. 4, the progress report on "The Elimination of Harmful Noise" will be presented and discussed.

Friday, Oct. 5, will be devoted to discussions of reports of safety in a number of manufacturing industries.

Dr. Samuel W. Grafflin, of the West Side Y. M. C. A., New York City, is to speak on "First Principles" at the opening session of the Public Utilities section. Dr. James S. Thomas, University of Alabama, Tuscaloosa, will dwell on "The Safety Man's Place in a Public Utility." After the election of officers there will be an illustrated talk on the use of slides in promoting safe operating practices.

On Wednesday morning there will be brief presentations relating to the past year's work, and a distribution of reports and addresses will be made by E. R. Dobbin, Chairman, Accident Prevention Committee, American Gas Association, and M. J. Kane, engineer in charge of plant training, American Telephone & Telegraph Company, New York City.

A joint luncheon will be held by members of both the Public Utilities and the Electric Railway Sections on Wednesday noon, when there will be a presentation of trophies to the winners in the utilities' safety contest and an address by Ernest W. Beck, vice-president of the National Safety Council.

On Thursday morning, H. B. Harmer, of the Philadelphia Electric Company, will deliver a timely address, after which there will be a discussion of "Pole Accidents." A playlet and movie, "Cloud and Sunshine," will be produced, through the courtesy of R. O. Bentley, of the Public Service Electric Light & Gas Company, Newark, N. J. "What's On Our Chests?" is the question that will be answered by several of the delegates who will participate in an informal discussion of accident prevention work in the utilities field. George Opp, of the Detroit Edison Company, will tell "What Are We Going to Do About It?"

What organized safety efforts can do for the refrigeration industries will be told when Charles B. Scott, past-president of the National Safety Council addresses a special session devoted to that industry. Vincent Wakefield, treasurer of the City Ice Company, of Kansas City, Mo., will preside as chairman of the Refrigeration Section.

"Why We Believe in Safety in Our Company" will be related by Wesley Oler, of the Knickerbocker Ice Company, New York, whose address will be followed by a general discussion.

Chairman Wakefield will talk about "How to Install a Safety Organization in the Refrigeration Industry," and L. C. Smith, secretary of the National Association of Ice Industries, Chicago, will answer the question, "Where Do We Go From Here?"

Second American Turbine-Electric Liner Launched

With the launching of the S.S. "Virginia," second of the three new turbine-electric passenger vessels for the Panama Pacific line of the International Mercantile Marine Company, another step has been taken in a program involving more tonnage of electrically propelled ships than ever before constructed by a single company. The "California," first of the three new vessels, was launched Oct. 1, 1927; the "Virginia" was launched Aug. 18, 1928, less than a year later, and the last of the three ships is now under construction and will probably be launched during the summer of next year. At the time of its launching the "California" was the largest electrically driven passenger vessel in the world, but its sister ship, the "Virginia," is still larger, and the third vessel will be a duplicate of the second.

The "Virginia" was launched at Newport News by its builders, the Newport News Shipbuilding & Dry Dock Company, which built the "California" and will also build the third boat. All three were designed for complete electric operation. The electrification includes the operation of auxiliaries in a very comprehensive manner, even the cooking and refrigeration being electrical.

The three vessels, the largest commercial steamships to be built under the American flag, are of twin-screw design, each propeller being driven directly by an 8,500-hp. motor. The electric energy for driving these motors is generated on each ship by two marine-type, General Electric steam turbines, each rated 6,750 shaft horsepower, 2,640 r.p.m., the latter corresponding to approximately 110 r.p.m. propeller speed. Each turbine has a maximum capacity of 8,500 shaft horsepower at 2,880 r.p.m. (120 r.p.m. propeller speed). These turbines are each direct connected to an alternating-current generator rated 5,250 kw., 2,640 r.p.m., 3,700 v., three-phase, and having a maximum continuous rating of 6,600 kw., 4,000 volts.

The propulsion motors are of the synchronous induction type, rated 5,250 kw., 110 r.p.m., 3,700 v., three-phase, 6,750 shaft horsepower. The maximum continuous rating of each motor is 6,600 kw., 120 r.p.m., 8,500 shaft horsepower. These motors are ventilated by four direct-currrent, motor-driven exhaust

fans automatically controlled. In normal operation each fan delivers 17,000 cu.ft. of air per minute for ventilating the motors.

Control of the propulsion machinery is accomplished through a main operating control panel divided into two sections, one for main high-voltage control and the other for low-voltage control of field circuits. Normal operation of the propulsion machinery is provided by the normal rating of the propulsion motors, or 13,500 shaft horsepower. The maximum continuous rated output of these motors (17,000 shaft horsepower) is for use from time to time as necessary to maintain schedules.

The steering gear consists of two 75-hp., 400-r.p.m., 230-volt, compound-wound, direct-current motors each driving a No. 50 Waterbury Tool Company variable-stroke pump supplying fluid to Hyde Windlass Company steering-gear plungers. Control of the plungers is located in the pilot house, and the motors can be started and stopped from either the engine room or the steering motor room. General Electric type magnetic contactor, non-reversing control equipment is used with the motors.

Steam for driving the turbines is furnished by 8 Babcock & Wilcox water-tube boilers with a pressure rating of 300 lb. gage and a superheat of 200 deg. F. These boilers are operated under forced draft with double-front furnaces equipped with oil burners. The exhaust steam is condensed by a set of four condensers—two for the main propulsion turbines, the largest ever installed in an American-built steamship, and two smaller ones for the four 500-kw. auxiliary turbine generators.

Electrification of the auxiliaries includes devices for the comfort and convenience of passengers, cargo and crew, such as elevators, dumb waiters, electric cooking equipment, deck cargo handling gear, boat handling equipment, warping winch, etc. Power for all auxiliaries, including refrigeration and lighting, is supplied by four 500-kw., General Electric turbine-driven generators which furnish direct current for this purpose and for exciting the propulsion motors.

Electric Industry Uses Nearly Half of Copper Supply

Almost one-half of the copper consumed in the United States in 1927 was used in the various branches of the electric industry, according to a survey made by the American Bureau of Metal Statistics.

Nearly 200,000 tons of copper were required for electrical manufacturing; telephones and telegraphs used 93,000 tons more, and electric light and power lines for transmission and distribution of current needed 108,000 tons. These three markets together accounted for 401,000 tons of the total consumption of 834,500 tons used throughout the country last year.

Of the copper used by the electrical industry, about 75 per cent went into power equipment and circuits, and 25 per cent into facilities for communication, says the report.

To this total can be added 4,500 tons used in radio receiving sets, 750 tons for electrification of steam railroads, and about 11,000 tons for electrical exports.

The most notable change in the proportionate consumption of copper appears in the item of light and power lines. This consumption increased four-fold between 1920 and 1927, during which time 11,000,000 new customers were added to the lines of the electric utilities.

Manufacturing Company Buys Back Its First Steam Engine

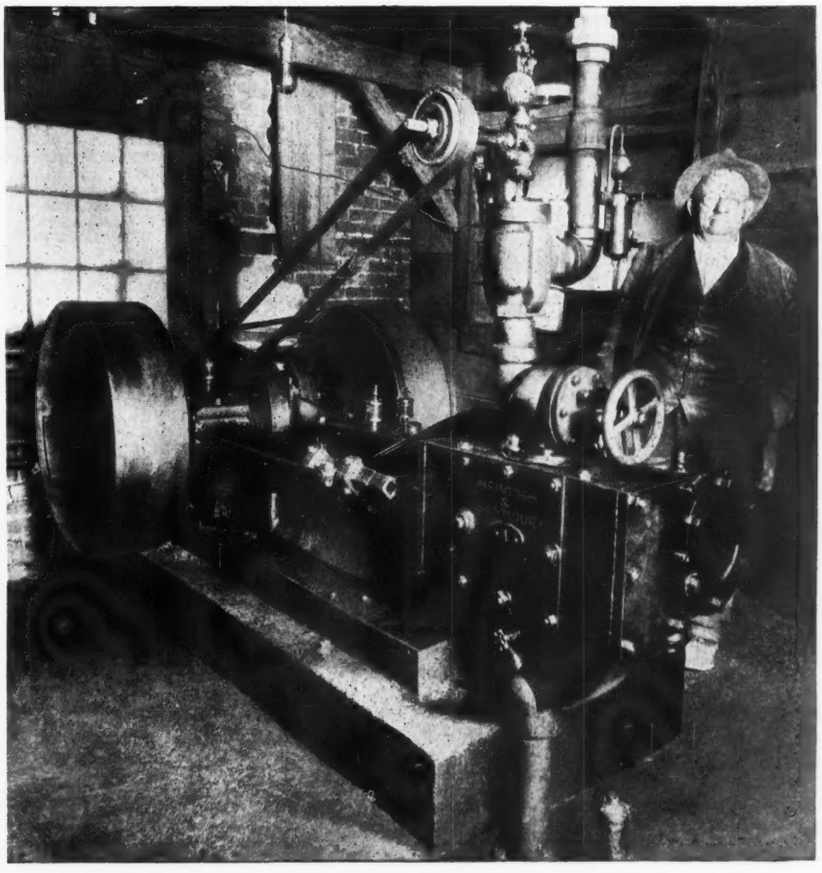
ENGINEERS are generally led to believe that the useful life of a steam engine is somewhere between 20 and 25 years. Many steam units have been retired after much shorter service because superseded by others of more efficient and economical design, but almost all of us have at one time or another seen some steam engine that has lived to a ripe old age and done good work for more than the alloted quarter of a century.

Such is the case with the first engine, built at Auburn, N. Y., in 1886, by John E. McIntosh and James A. Seymour, of the firm which has since become the McIntosh & Seymour Corporation. This veteran had for many years been lost to the builders and was discovered through an order for a minor repair part. Investigation showed that it had been through two fires, the latter of which bankrupted the first owner and left his plant a mass of ruins. During the following year the engine was abandoned and exposed to sun, rain, snow and ice. The second owner accepted it to satisfy partly an unpaid note and, after an overhauling, put it back to work in a lumber mill in Moravia, N. Y.

It is rated at 40 hp., runs at 300 r.p.m., and in its second location drove a circular saw from the belt shown on the right flywheel in the illustration.

Out of sentiment, this engine has been bought back, and is to occupy an honored place in their present plant.

McIntosh & Seymour expanded in the steam field until in 1913, some 1,800 steam engines of various stationary types and sizes up to 10,000 hp. had been built. In 1914 it withdrew from the steam field and has since confined its activities entirely to Diesel engines of stationary and marine types.



This forty-two year old engine was still in service when found by its builder

Standardization Proposed for Leather Belting

Because leather belting valued at about $30,000,000 is being purchased each year without accurate knowledge of its suitability for specific conditions of use, wearing qualities in service, or proper methods of maintenance, the American Society of Mechanical Engineers has asked the American Engineering Standards Committee to authorize the establishment of definite standards for leather belting as a guide to industrial purchasers.

This proposal is now being considered by the Executive Committee of the Standards Committee. If approved, the work will be undertaken shortly, covering, as requested by the Society: (1) Quality (standard material specification); (2) capacity (horsepower rating); (3) weight (dimensions, thickness and weight); (4) care and maintenance of belting.

Precedent for belting standardization is found in the work of the American Petroleum Institute, which has established standards for all types of belting used in the oil industry. The Institute estimates that its specifications and recommendations for care and usage increase the service value of belting purchases by 25 per cent.

Belting used in oil fields is subjected to unusually variable and harsh conditions of service, due partly to the temporary character of installations and the severe nature of the loads. It is believed that the oil industry's success with standardization of belting could be duplicated in other fields. A saving to all industries on the basis of 25 per cent estimated for the oil industry would mean that the purchasers of leather belting in the United States would be saved over $7,000,000 annually.

The results of research work conducted by the American Petroleum Institute and other organizations in connection with standards for belting will be studied by the sectional committee which will be organized following approval of the project by the American Engineering Standards Committee. The committee will include in its membership representatives of manufacturers and users of leather belting, and of other interests concerned with the subject.

It is pointed out that such standardization, and the broader use of the test data underlying it, would lead to a great increase in the present knowledge of the properties of leather belting.

New York Schools to be Used for Ventilation Experiments

An experiment in ventilation is to be made next fall in several public schools by the New York Commission on Ventilation, under the auspices of the Milbank Memorial Fund. Acting Superintendent of Schools Dr. Harold G. Campbell believes that "these experiments will be of great value in planning the ventilation of new buildings."

In sixteen rooms in Public School 116, Manhattan, comparison is to be made of the effects on the health of the children of the present mechanical ventilation system working at a normal rate (30 cu.ft. of air per child per minute) and the same system working at a reduced rate (15 cu.ft. of air per child per minute).

In Public School 104, Manhattan, it is proposed to make a comparison between the mechanical ventilating system at a reduced rate (15 cu.ft. of air per child per minute) and window gravity ventilation (ventilation without a mechanical draft). The same experiments are to be carried out in two other schools, to compare the results in different neighborhoods.

Coming Conventions

American Society of Mechanical Engineers, Twin-City regional meeting at St. Paul, Aug. 27-30; Boston regional meeting, Oct. 1-3; second national fuels meeting at Cleveland, Ohio, Sept. 17-20; Calvin Rice, secretary, 29 West 39th St., New York City.

American Welding Society, fall meeting at Philadelphia, Pa., Oct. 8-12; M. M. Kelly, secretary, 29 West 39th St., New York City.

Canadian Steel and Power Show at the University of Toronto Arena, Sept. 4-7; Campbell Bradshaw, secretary, 24 Front St., West Toronto, Canada.

Midwest Power Conference and Exhibition, at Chicago, Feb. 12-16; G. E. Pfisterer, secretary, 53 West Jackson Blvd., Chicago.

National Association of Power Engineers, annual convention at Detroit, Sept. 11-15, and concurrently National Exhibitors' Assn. exhibit; Fred Raven, 417 South Dearborn St., Chicago.

National Association Practical Refrigerating Engineers, annual convention at Louisville, Kentucky, Nov. 20-23; E. H. Fox, secretary, 5707 West Lake St., Chicago, Ill.

National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York City, Dec. 3-8. Address inquiries to the International Exposition Company, Grand Central Palace, New York City.

New England Water Works Association, annual convention at Montreal, Canada, Sept. 18-21, Frank J. Gifford, secretary, 715 Tremont Temple, Boston, Mass.

Stoker Manufacturers Association, fall meeting at Greenbrier Hotel, White Sulphur Springs, W. Va., Oct. 22-24.

Second Bituminous Coal Conference will be held at Pittsburgh, Nov. 19-22.

World Power Fuel Conference at the Imperial Institute, London, Sept. 24 to Oct. 6.

N. Y. Edison Installs Largest Supervisory Control Equipment

The largest single supervisory control equipment in the world is being assembled for the New York Edison Company by the Westinghouse Electric & Manufacturing Company at East Pittsburgh, Pa. The equipment will be installed in New York City to control the Riverside substation at 238th Street from a dispatching office located in the 188th Street station.

The supervisory equipment is of the synchronous visual type and is entirely mounted on standard steel switchboard panels. The equipment is arranged to control and supervise ultimately 115 pieces of apparatus, supervise only 43 pieces of apparatus and indicate 95 selective remote meter readings. The apparatus controlled consists of high- and low-tension breakers, bus tie and bus grounding breakers, feeder breakers, voltage regulators, blower motors and battery charging m.g. sets. Supervision only is provided for transformer temperatures, live lines, battery voltages, potential transformer fuses, battery and bus ground detectors, station service automatic transfer switch and substation door. The remote metering gives indications of transformer and low-tension feeder currents, regulator and bus voltages, and incoming high-tension lines and transformer load.

The dispatcher's control keys and indicating lamps are arranged in a single line diagram of the substation and connected by a minature bus. In the substation controlled, there are control panels that are substantially duplicates of the dispatcher's control panels to provide for the local substation control. This feature is unique in that the conventional local control switches are replaced by the supervisory control type of keys and lamps, thereby eliminating a large part of the usual control equipment, reducing space requirements to a minimum.

Industry Has Approved 95 Simplifications

With the completion of seven new simplified practice recommendations during the second quarter of 1928, industries have now developed a total of 95 simplifications in co-operation with the Division of Simplified Practice, of the Bureau of Standards, United States Department of Commerce.

Ray M. Hudson, assistant director in charge of the Commercial Standards Group of the Bureau of Standards, of which the Division of Simplified Practice is a part, has just rendered a report, covering the activities for the quarter ending June 30, 1928, to Dr. George K. Burgess, director of the bureau.

"During the quarter, a total of nine simplified practice recommendations came before the respective standing committees for review," said Mr. Hudson, in reviewing the report. "Three were revised, five were reaffirmed, and one, Simplified Practice Recommendation No. 28—Sheet Steel, the standing committee deemed necessary to divide into two portions, to be published separately, one on sheet steel and the other on iron and steel roofing—the latter to be known as Simplified Practice Recommendation No. 78.

"Of the nine recommendations reviewed, six were supported by factual surveys, while estimates of adherence were accepted for two, and one was reaffirmed without either a resurvey or estimate. The average degree of adherence as determined by surveys was 83.97 per cent for the six recommendations. The estimated adherence for the two, without surveys, was 80 and 89 per cent, respectively. Adding the 80 and 89 per cent to the 83.97 per cent, the average degree of adherence for the

quarter was 84.32 per cent. During the quarter the total number of acceptances to adopted simplified practice recommendations increased from 9,465 to 10,637.

OBITUARY

WAYLAND LLOYD ARNOLD, widely known in the electric and public utility field, died suddenly on July 28, in his home at Chicago, Ill. Mr. Arnold was born in Jackson, Mich., but spent the early years of his life at Ashland, Neb. In 1890 he joined the Thomson-Houston Electric Company, which later became the General Electric Company. After a number of years in charge of the St. Louis office he became connected with the Arnold Engineering Company, engineers and constructors, remaining there as vice-president until 1926. In the meantime he had also become vice-president of the Elgin & Belvidere Electric Railway Company, holding both offices until his retirement from active business in 1926.

WILLIAM MAVER, JR., author and electrical engineer, died at his home in Jersey City, N. J., at the age of 76. He was born in Scotland and moved to Canada with his parents when he was six years old. In 1873 he came to New York. He was electoral public utility expert for many companies and in much electrical patent litigation. For four years, beginning in 1880, he served as expert for the Western Union Telegraph Company and later was associated with Safety Insulated Wire & Cable Company, the Consolidated Telegraph & Electrical Subway Company, New York Heat, Light & Power Company, and the Baltimore & Ohio Telegraph Company. He was the owner of the publishing company bearing his name and was a member of the New York Electrical Society, Association of Railway Telegraph Superintendents, Old Time Telegraphers and Historical Association. He was the author of several works on electrical engineering as well as numerous technical articles.

BUSINESS NOTES

THE CONSOLIDATION COAL COMPANY announces the appointment of W. T. Coe as assistant to vice-president with offices at 15 Broad St., New York City. Mr. Coe will have supervision of the distribution department and active management of the export department.

THE AMERICAN BROWN BOVERI ELECTRIC CORPORATION, Camden, N. J., has purchased the transformer division of the Packard Electric Company, Warren, Ohio. The manufacture of transformers will be continued in all types and sizes under the established trademark "Packard." N. A. Wolcott, president of the Packard Electric Company, will become affiliated with the American Brown Boveri Company.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY has announced the winners of the 1928 competition for its War Memorial Scholarships. The successful candidates are: Paul S. Marthens, 944 Sycamore St., Turtle Creek, Pa.; Winton M. Dudley, Fifteenth St., Oakmont, Pa.; Marshall A. Wilson, 9737 Vanderpoel Ave., Chicago, and D. Gordon Sharp, 40 Prospect St., Bloomfield, N. J. The scholarships, which are awarded annually in memory of Westinghouse employees who served in the World War, provide annual payments of $500 each to be applied toward a four-year engineering education in any technical school or college that the winner selects. They are allotted by means of competitive examinations to youths who are either employees of the company or sons of employees.

PERSONALS

O. R. BAILLY, formerly connected with the Testing Department of the General Electric Company at the Schenectady and Pittsfield works, is now identified with the South American properties controlled by the Electric Bond & Share Company.

P. H. SCHWEITZER, associate professor of research at Pennsylvania State College, is going abroad at the end of this month to take his Doctor's degree at a German university. Before returning he will confer with the leading builders of Diesel engines in Europe. Professor Schweitzer is in charge of the Diesel oil spray research at Penn State. During his absence H. J. De Juhasz will substitute for him in conducting the investigation.

TRADE CATALOGS

STEAM JET VACUUM PUMP—Schutte & Koerting Company, Philadelphia, has issued Bulletin No. 5-B describing its complete line of multi-nozzle steam-jet vacuum pumps, which are built in five standard types. The types include multi-nozzle steam jet exhauster, multi-nozzle steam-jet vacuum booster, two-stage steam-jet vacuator, hydro-steam vacuum pump and three stage steam-jet vacuator. Colored illustration showed the design of the pumps and the text clearly explains the construction features of the pump and their application in power and process work.

ELECTRIC DUMB WAITERS — The Warner Elevator Manufacturing Company, Cincinnati, O., has recently issued new bulletin, A Treatise on Warner Electric Dumb Waiters. This publication describes the construction and operation of the company's Type F-18 electric dumb waiter.

MOTOR STOCK LIST — The Diehl Manufacturing Company, Elizabethport, N. J., has issued a comprehensive stock sheet to be known as the "Orange Stock List." This sheet is distributed the first and fifteenth of each month to those interested in motors and exhaust fan equipment. The list includes several types of direct- and alternating-current motors, ventilating and exhaust fans, direct-current generators, marine-type motors and generators, and motor-generator sets.

CELITE IN CONCRETE—Celite and its use in concrete to improve the cohesive workability, is described in a little bulletin just issued by the Celite Products Company, 1320 South Hope St., Los Angeles, Calif. Illustration of architectural designs, concrete pipe and buildings in which Celite has been used in the construction are included.

DIRECT-CURRENT MOTORS AND CONTROL—Catalog GEA-861 of the General Electric Company, Schenectady, N. Y., describes the company's class BM direct-current motors and control, which are built in accordance with the requirements of the U. S. Bureau of Mines for equipment permissible in gassy mines.

FUEL PRICES

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.25@$2.60
Kanawha	Columbus	1.25@ 1.60
Smokeless	Cincinnati	2.00@ 2.25
Smokeless	Chicago	2.00@ 2.25
S. E. Kentucky	Chicago	1.35@ 1.60
Steam	Pittsburgh	1.80@ 1.90
Gas Slack	Pittsburgh	1.20@ 1.30
Big Seam	Birmingham	1.25@ 1.75
Anthracite (Gross Tons)		
Buckwheat	New York	$2.75@$3.00
Birdseye	New York	1.60

FUEL OIL

New York—Aug. 16, f.o.b. Bayonne, N. J.: 28@34 deg., Baumé, industrial use, tank-car lots, 5c. per gal.; 36@40 deg., furnace, tank-car lots, 7c. per gal.

St. Louis—Aug. 10, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.35 per bbl.; 26@28 deg., $1.40 per bbl.; 28@30 deg., $1.45 per bbl.; 30@32 deg., $1.50 per bbl.; 32@36 deg., gas oil, 4.15c. per gal.; 38@40 deg., 5c. per gal.

Pittsburgh—Aug. 8, f.o.b. local refinery, 30@34 deg., fuel oil, 5½c. per gal.; 36@40 deg., 5¾c. per gal.

Philadelphia—Aug. 13, 26@30 deg., $2.00@$2.07 per bbl.; 13@19 deg., $1.05 @$1.12 per bbl.; 22 plus, $1.48@$1.55 per bbl.; 27@30 deg., $2.10@$2.17 per bbl.

Cincinnati—Aug. 13, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—Aug. 11, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl.: 22@26 deg., 57½@60c. per bbl.; 26@30 deg., 75c. per bbl.; 30@32 deg., 90c. per bbl.

Boston—Aug. 13, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.35c. per gal.; 28@ 32 deg., 5.55c. per gal.

Dallas—Aug. 1, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Ark., Helena—West Helena Water Works Co., c/o North American Water Works Corp., 39 Broadway, New York, N. Y., will build an addition to power plant, 250,000 gal. storage reservoir, etc. Estimated cost $50,000. Private plans.

Calif., Los Angeles—Los Angeles County Bd. of Supervisors, will receive bids until Aug. 27, for construction of a 13 story 600 x 400 ft., hospital including steam heating and refrigeration system, 15 elevators, etc. Estimated total cost $8,000,000. E. Bergstrom, M. Hunt, 4205 Spring St., Associates are architects.

Calif., Oceanside — City to vote bonds $110,000 for the construction of wells, pump and booster plant and reservoir, etc. R. L. Loucks, is city engineer.

Calif., Sacramento—Coffman, Sahlberg & Stafford, Plaza Bldg., Archts. taking bids for the construction of public market buildings, loading platform, ice and cold storage plant, etc. at Alhambra Blvd. & Granada Way, for Syndicate. Estimated cost $200,000.

Fla., Gainesville—State Bd. of Control, Tallahassee, will soon let contract for central heating plant for University of Florida. R. Weaver, Gainesville, is architect.

Fla., Palmetto—City awarded contract for improvements to power plant to Main Engineering Co., Daytona Beach. $35,000.

Fla., St. Petersburg—City awarded contract for construction of a cold storage warehouse to J. P. Jones, cost $250,000. E. B. Hadley, St. Petersburg is architect.

Ga., Valdosta — City Council has appointed M. T. Singleton, Atlanta, construction engineer to make survey of city water plant and prepare plans for installing new equipment to be electrically operated.

Ill., Chicago—John R. Thompson Co., 350 North Clark St., will receive bids about Aug. 20, for a 23 story office and stores building including ventilation system, etc. at 23-19 West Randolph St. Estimated cost $3,000,000. A. S. Alschuler, Inc., 28 East Jackson Blvd., is architect.

Kan., Belleville — City voted $120,000 bonds for waterworks improvements including 2 pump houses, wells, etc.

Ky., Paducah — City election Nov. 7, to vote $800,000 bonds for the construction of a power plant. Burns & McDonnell, 402 Interstate Bldg., Kansas City, Mo., are engineers.

La., Alexandria—U. S. Veterans Bureau, 764 Arlington Bldg., Washington, D. C., awarded general contract for hospital to consist of 23 buildings to N. P. Severin Co., 222 West Adams St., Chicago, Ill., heating to Redmond Heating Co., 124 North 4th St., Louisville, Ky., and electrical work to R. A. Phelps, Beloit, Wis.

Mass., Fall River—Ice Utilities Inc., c/o Funk & Wilcox, 26 Pemberton Sq., Boston, archt., awarded contract to Marden & Orlando, 46 Cornhill, for the construction of an ice plant on Lowell St., here. Estimated cost $100,000. York Ice Machinery Corp., 200 Causeway St., Boston, is engineer.

Mass., Nantucket—Town, W. E. Godd, Chm. of Commission, is taking bids for the construction of sewage system including pumping station. Estimated cost $40,000 or more. Weston & Sampson, 14 Beacon St., Boston, Mass. are engineers.

Mass., Salem — Park Leather Co., 55 Grove St., taking bids for 1 story, boiler house and plant addition. W. H. Hunt & Son, 208 Essex St., are architects.

Mass., Waltham — Dept. of Mental Diseases, State House, Boston, will receive bids until Aug. 23, for 5 continued treatment buildings and boiler house at Metropolitan Hospital. G. Robb, 14 Beacon St., Boston, is architect.

Mo., St. Louis—C. Anschuetz, 3503 Sidney St., awarded contract for the construction of 10 story 117 x 250 ft., apartment including steam heating system, 3 elevators, electrical work, etc., to Boaz-Kiel Constr. Co., Ambassador Theatre Bldg. Estimated cost $1,000,000.

N. J., Haddon Heights—Borough will receive bids until Sept. 4, for sewer pumping plant in Fairfield Section. Estimated cost $40,000.

O., Cleveland—Dept. of Welfare, J. E. Harper, Dir., Columbus, awarded general contract for 40 x 60 ft. power house at Hawthome Farm to J. G. Woide, Cleveland, $29,800.

O., Gallipolis—Dept. of Welfare, J. E. Harper, Dir., Ninth and Oak Sts., awarded contract for remodeling of an ice and cold storage plant for Institution for Epileptics to J. B. Dale & Son, installation to United Cork Co., Cincinnati.

O., Orrville—Bd. of Public Affairs, Municipal Water, Light & Ice, A. D. Webster, Supt., awarded contract for extension and reconstruction of municipal plant boiler room structure. Estimated cost $17,000.

R. I., Providence—Providence Wholesale Food Terminal c/o Jenks & Ballou, archts, Grosvenor Bldg., awarded contract for the construction of a 2 story, 60 x 965 ft., produce terminal including warehouse, cold storage building, power plant, refrigerating plant, service and administration buildings on Kingsley, Harris & Allens Aves., to Turner Construction Co., 178 Tremont St., Boston, Mass. Estimated cost $3,000,000.

Tex., Beaumont—Peoples Light & Power Corp., c/o E. C. Deal, Pres., 27 William St., New York, N. Y., has acquired the Neches Water Co. property and plans improvements to include extension to distributing system, pumping equipment, etc.

Ont., Niagara Falls—Niagara Falls Water Comn., having plans prepared for filtration plant and power house. Estimated cost. $500,000. F. B. Dallyn, 71 King St. W., Toronto, is engineer.

Equipment Wanted

Air Compressor—Bd. of Purchase, H. C. Cain, Secy., City Hall, Columbus, O., will receive bids until Aug. 23, for portable gasoline driven air compressor for Engineering Dept.

Boiler — Bd. Public Affairs, St. Louis, Mo., making preliminary plans for installation of 500 hp. boiler with stoker breechings, etc., in connection with proposed addition to power plant. L. R. Bowen, 301 City Hall, is engineer.

Boilers, etc. — City of Chillicothe, Mo. plans installation of 1,500 hp. motor tube boiler and 1,500 hp. feed water heater in connection with boiler plant improvements. E. E. Harper, 4010 Penn St., Kansas City, Mo., is engineer.

Electric Power Plant Equipment, etc.—P. Hayworth, Bruce Mines, Ont., plans to equip gravel handling, washing and loading plant, also electric power plant at Hilton Beach. Estimated cost $350,000.

Oil Burner Equipment and Heating Installations—Bd. of Education, San Antonio, Tex., will soon take bids for supply and installation of oil burning equipment in six schools also heating installation in one school. Phelps & DeWeese, 718 Gunter Bldg., San Antonio, are architects.

Power Plant Equipment — Bureau of Yards, Navy Dept., Washington, D. C., soon takes bids for power plant equipment, Quantico, Va. Spec. 5602.

Pumps — City of Yankton, S. D. will receive new bids for pumps, etc., in connection with waterworks improvements. Former bids rejected. Burns & McDonnell Engr. Co., 402 Interstate Bldg., Kansas City, Mo., are engineers.

Pumping Equipment, etc.—City of Dallas, Tex., c/o M. G. James, City Secy., will receive new bids on revised plans until Sept. 7, for furnishing and installing two 15 m.g.d. turbine driven pumping units complete; three 15 m.g.d. motor driven pumping units, complete with motors; two 1,000 kw. turbo generators, complete with auxiliaries and three 300 hp. water tube boilers. J. B. Winder is chief engineer.

Industrial Projects

Calif., Vernon—OIL REFINERY—Swift & Co., 916 E. 1st St., Los Angeles, taking bids for construction of a 2 and 4 story 114 x 213 ft., oil refinery at Los Angeles St., between Vernon and 39th Sts. Estimated cost to exceed $40,000. Architectural Dept. of owner, Chicago, Ill., are architects.

Conn., Bridgeport — AIRPLANE FACTORY — Huntington Aircraft Corp., H. Huntington, Pres., Newfield Bldg., plans construction of an airplane manufacturing plant. Estimated cost $100,000 or more.

Conn., Stratford — BRAKE LINING PLANT—Raybestos Co., Railroad Ave., awarded contract for the construction of a brake lining plant to W. J. Shaugnessy Jr., Inc., Fairfield Ave. Estimated cost $40,000 or more. Private plans.

Ga., Rome — RAYON MILL — American Chatillon, 393 7th Ave., N. Y., awarded contract for the construction of a rayon mill to Hughes Foulkrod Co., Shaff Bldg., Phila., Pa. Estimated cost $4,000,000. Lockwood, Green & Co., 1 Pershing Square, New York, N. Y., are engineers.

Mass., Lynn—SHOE FACTORY ADDITION AND HEATING PLANT—Bender Shoe Co., M. F. Costigan, Pres., 95 State St., having revised plans prepared for construction of a factory addition and heating plant. Sanborn & Weed, Item Bldg., are architects.

Mich., Detroit—ENGINEERING, SHIPPING, etc.—Hupp Motor Car Co., 3461 East Milwaukee St., awarded contract for engineering, shipping and storage building including loading docks to Everett Winters Co., 1651 E. Grand Blvd. Estimated cost $1,500,000. Private plans.

N. Y., Brooklyn—COKE SCREENING PLANT—Brooklyn Union Gas Co., 176 Remsen St., having plans prepared for the construction of a coke screening plant, Gardener Ave. Estimated cost $175,000. Koppers Constr. Co., Union Terminal Bldg., Pittsburgh, Pa., are engineers.

Va., Covington—FACTORY and POWER PLANT—Industrial Fibre Co., W. 98th St. and Walford Ave., Cleveland, O., awarded contract for the construction of a 330 x 831 ft., factory and power plant to Fiske-Carter Constr. Co., Worcester, Mass. Estimated cost $1,000,000.

Wis., Milwaukee — FACTORY — International Harvester Co., 606 S. Michigan Blvd., Chicago, Ill., awarded contract for the construction of a 3 story factory bldg. addition to Dohlman Constr. Co., 456 Broadway, Milwaukee. Worden-Allen Co., Milwaukee and Chicago, are architects.

Wis., Milwaukee — STEEL TUBE FACTORY — Globe Steel Tube Co., will build a 1 story, 200 x 300 ft., factory addition with owners forces. Private plans.

O., Portsmouth — SHOE FACTORY — Selpy Shoe Co., plans the construction of a shoe factory. Estimated cost $300,000.

N. B., Dalhouse—PAPER MILL—International Paper Co., 100 East 42nd St., New York, N. Y., has awarded contract for construction of buildings for a new paper mill here, to Domill Constr. Co., Montreal. Estimated cost $3,000,000. Owner will soon take bids for machinery, mechanical equipment, etc.

Ont., Mount Denis—BOX FACTORY—First Brook Bros., 283 King St., E., Toronto, having plans prepared for the construction of a box factory including boiler plant. Estimated cost $250,000. Chapman & Bxley, Northern Ontario Bldg., Toronto, are architects.

Ont., Toronto — MOTOR BODY FACTORY — Smith Bros., 188 Duke St., plan the construction of a motor body factory on Logan St. Estimated cost. $150,000. Engineer and architect not selected.